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THE IMPACT OF WAR ON MILITARY HOSPITAL PERFORMANCE: A STUDY OF ORGANIZATIONS' RESPONSE TO AN ENVIRONMENTAL JOLT

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THE IMPACT OF WAR ON MILITARY HOSPITAL PERFORMANCE: A STUDY OF ORGANIZATIONS' RESPONSE TO AN ENVIRONMENTAL JOLT

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Abstract

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The prolonged wars in Iraq and Afghanistan have taken a toll on the United States as a whole and the United States military in particular. The primary aim of this research is to determine what impact the wars in Iraq and Afghanistan have had on the performance of military hospitals over the fiscal years 2001-2006. Specifically, what direct effect has the war in Iraq and Afghanistan had on the productivity and quality of military hospitals, and, do productivity and quality trends differ based on hospital characteristics? Since observations over multiple time periods are nested within hospitals, multilevel mixed effects regression and Poisson regression models are used to evaluate changes in productivity and quality while accounting for differences within hospitals. Using a contingency theory framework, this study fills the gap in looking at the impact of war on permanent military hospitals' productivity and quality using nationally

developed and implemented quality indicators (Agency for Healthcare Quality and Research Inpatient Quality Indicators and Patient Safety Indicators).

Structural characteristics of the hospital, teaching status and branch of Armed Service influenced productivity and certain quality indicators. The structural components were not able to reliably predict differences in productivity and all quality indicators, but overseas hospitals and non-teaching hospitals were most likely to differ from major teaching hospitals. The wars in Iraq and Afghanistan, denoted by the variables for wounded discharges and deployed staff, were only partially related to the productivity of military hospitals. Only an increase in the percentage of wounded discharges was related to productivity of military hospitals, and none were related to the quality indicators. In essence, the war affected the workload and productivity of military hospitals, but it did not affect the quality provided in the hospitals, as measured by AHRQ inpatient and patient safety quality indicators. Structural characteristics account for more of the variation in quality among military hospitals than the impact of war within the timeframe studied.

Chapter 1: Introduction

Operation Iraqi Freedom began when President George W. Bush gave the order to invade Iraq on March 19, 2003 (White House, 2003). At the time, over 340,000 United States military troops were staged in the Persian Gulf region (Bowman, 2003). The traditional military offensive lasted less than two months. On May 1, 2003, President Bush declared the end of major combat operations in Iraq in front of the now infamous "Mission Accomplished" sign (CNN, 2003). Stability operations that followed the end of combat operations have taken a greater toll on the United States military than the initial offensive. The lack of initial control by the United States soon led to a sectarian civil war in Iraq. After the troop surge in 2007 and strengthening of the Iraqi government, Iraq became less volatile. As violence receded in Iraq, the United States military confronted escalating violence in Afghanistan. By the end of October 2007, over 1.6 million United States service members had been deployed to the conflicts in Iraq and Afghanistan (Tanielian & Jaycox, 2008). Since the final military troop presence left Iraq on December 31, 2011, it is fitting to look back to see how the Iraqi Conflict affected the Military Health System in the United States.

The conflicts in Iraq and Afghanistan were the first prolonged combat operations that the United States has fought with an all volunteer force, and the operations tempo has been unprecedented (Tanielian & Jaycox, 2008). At the same time, advances in battlefield medical care, air evacuation, and equipment such as body armor have increased not only the number of wounded patients returning to military hospitals when compared to previous wars, but also the

acuity of those wounded patients (Montgomery, Swiecki, & Shriver, 2005; Tanielian & Jaycox, 2008). Goldberg (2010) compares the wounded to hostile death ratio of Iraq and Afghanistan (9.2 to 1) to Vietnam (6.4 to 1) using Congressional Budget Office data through January 2007.

The wounded patients are treated in mobile military hospitals in the theater of operations. The military has two types of hospitals: mobile and permanent. Mobile military hospitals (such as fleet hospitals and combat support hospitals) deploy with combat units to provide medical care in the theater of operations. Permanent military hospitals provide inpatient and outpatient health services, including primary and specialty care, to wounded patients evacuated from the theater of operations as well as Department of Defense (DOD) beneficiaries. Beneficiaries include active duty uniformed service members, retirees, their respective family members, and surviving dependents of deceased service members (TRICARE, 2008-a). As wounded soldiers return to military medical centers and hospitals in the United States for recuperation, these facilities must adapt in order to treat both their normal peacetime patients and these high acuity wartime patients. The permanent military hospitals are the subjects of this study.

Study Purpose

The primary aim of this research is to determine what impact the wars in Iraq and Afghanistan have had on the productivity and quality of United States military hospitals over the fiscal years (FY) 2001-2006. By doctrine, military hospitals in the continental United States provide definitive care for the members of the armed forces who are wounded in action. Due to the medical advances briefly noted above, wounded patients arriving at military medical centers require extensive surgery and medical intervention in addition to rehabilitation that was required in previous military conflicts. In addition, rehabilitation of these serious wounds is much more extensive than before, leading to the opening of two Centers of Excellence: National Intrepid

Center of Excellence (NICoE) for Psychological Health and Traumatic Brain Injury in 2010 and Center for the Intrepid (CFI) for amputee care in 2007. The military hospitals must also contend with losing military nurses, physicians, allied health professionals and administrative personnel to operational combat units deployed to Iraq and Afghanistan. During times of war and contingency operations, military medical personnel assigned to hospitals and clinics are attached to operational forces (e.g., combat support hospitals, expeditionary medical facilities, and brigade combat teams) as they deploy. The hospital staff may also succumb to compassion fatigue (Stewart, 2009) while treating the wounded soldiers as well as dealing with possible traumatic stress from hostile situations from their own deployment (Gibbons, Hickling, & Watts, 2012). The increase in workload, turnover in staff, stressors related to war, increased training requirements and preparations for deployment may negatively influence efficiency in military hospitals. In the meantime, the focus of peacetime medicine has been on increasing cost efficiency through increases in productivity and quality. In light of these dueling objectives, the two research questions in the study are:

1) Overall, how did productivity and quality change over the years 2001-2006 in military hospitals? Specifically, what direct effect has the war in Iraq and Afghanistan had on the productivity and quality of military hospitals?

2) Do productivity and quality trends differ over the years 2001-2006 by type of hospital?

Military hospitals provide inpatient care as well as outpatient primary and specialty care. The factors that affect quality and productivity for the inpatient setting may be different from the outpatient setting, especially since quality and productivity measures differ for the two settings. For the purposes of this study, only services provided in the inpatient setting are analyzed. Quality in the inpatient setting is assessed using inpatient quality indicators. This study uses peer

reviewed measures developed by the Agency for Healthcare Quality and Research. The inpatient quality indicators (IQIs) and patient safety indicators (PSIs) should reflect quality of inpatient hospital care focusing on mortality (IQIs) and potentially avoidable complications (PSIs).

Data and Analysis

This study analyzes military hospitals over a six-year period from FY 2001 to FY 2006. The Military Health System (MHS) Data Repository (MDR) is a "data warehouse containing the most complete collection of data about healthcare provided to beneficiaries of the MHS" (TRICARE Management Activity, 2010, p. 4). The MDR stores over 10 years of clinical and financial data for all military hospitals and clinics and is the primary database for this dissertation. Data from the numerous information systems in the MHS are funneled to the centralized MDR enabling corporate decision making at all levels: hospital, region, branch of service and MHS.

Data are collected in a panel design with quality and productivity measures recorded for each hospital every fiscal year over a six year period of time. The time period FY 2001 to FY 2006 covers one year before U.S. forces entered Afghanistan to the year prior to the surge in Iraq in 2007. The MHS also underwent a transformation following the Quadrennial Defense Review in 2006, which is outlined in the MHS Strategic Plan entitled "A Roadmap for Medical Transformation" (Military Health System, 2008). In order to assess the quality and productivity of military hospitals prior to the transformation and change in strategy, data for this study were gathered through FY 2006. The final dataset includes hospital characteristics such as branch of service and teaching status as well as number of deployed staff, number of wounded discharges, nurse and clinician staffing, contract staffing, case mix index, and productivity and quality measures. Quality measures were calculated with the Agency for Healthcare Research and

Quality's (AHRQ) Quality Indicators Software (AHRQ-b, 2006). The software uses individual discharge information for each hospital extracted from the MDR to formulate applicable patient safety indicators (PSI) and inpatient quality indicators (IQI), which became dependent variables in the study. Both IQIs and PSIs reflect the quality of care, focusing on the processes, during the hospital stay (Coffey et. al., 2010).

Observations over multiple time periods are nested within hospitals. Therefore, to determine change in productivity over the period of the study, a multilevel mixed effects model using a random coefficient modeling framework is used. To determine change in quality over time, a multilevel mixed effects model with Poisson regression is used because the quality variables are counts of deaths or adverse events.

Significance of the Study

There are few studies of military hospitals during wartime. Most of the focus of study has been on mental health utilization following deployment (Hoge, Auchterlonie, & Milliken, 2006; Hoge et al., 2004; Erbes, et al., 2007; Thomas et al., 2010; Kok et al., 2012) or descriptive studies of types of war injuries and deployed unit experiences (Cancio et al., 2005; Murray, et al., 2005; Fox et al., 2005; Zouris, Walker, Dye & Galarneau, 2006). Studies of quality do not directly link to the association between changes in quality to the wars in Iraq and Afghanistan. With the emphasis on transparency in government run health care, it is important that military hospitals utilize the same quality metrics as the rest of the healthcare sector. This study fills the gap in looking at the impact of war on permanent military hospitals' productivity and quality using nationally developed and implemented quality indicators. Results from this study increase the understanding of military hospitals' response over time as reflected in the changes in productivity and quality.

Organization of the Dissertation

The purpose of this study is to determine what impact the wars in Iraq and Afghanistan have had on the productivity and quality of military hospitals. The introduction outlined the rationale for conducting the study. The literature review in Chapter 2 provides more insight into the military health system and the roles of military hospitals, information about the wars in Iraq and Afghanistan, and the current state of hospital performance measurement. Chapter 3 delineates the theoretical framework based on Contingency Theory and the conceptual model for the study. The data and analytical methods are explained in Chapter 4 with results of the analysis contained in Chapter 5. Chapter 6 provides the discussion of the results with limitations and implications.

Chapter 2: Literature Review

Military Health System

The Assistant Secretary of Defense (Health Affairs) is responsible for all health policies, programs, and activities for the DOD. The mission of the Military Health System (MHS) in 2006 was "[t]o enhance the Department of Defense and our Nation's security by providing health support for the full range of military operations and sustaining the health of all those entrusted to our care" (Military Health System, 2006, p. 3). As the quote illustrates, the MHS has a two-fold mission: operational support and beneficiary care. The MHS needs to be prepared to provide health care services before, during and after deployments in support of military operations. In addition, the beneficiary mission provides peacetime healthcare services to active duty military, their family members, and others entitled to DOD healthcare. Indeed, the 2006 MHS Strategic Plan states that there are two main, but not mutually exclusive, customer groups: 1) commanders and service members; and 2) beneficiaries. With the updated MHS Strategic Plan in 2008, "Our team provides optimal Health Services in support of our nation's military mission – anytime, anywhere" became the new mission statement for the MHS (Military Health System, 2008, p. 2).

The MHS provides health care for 9.7 million DOD beneficiaries with expenditures over $52 billion per year (Military Health System, 2012). The care is provided by a combination of direct care (care delivered in health care facilities directly operated by DOD agencies) and purchased care (care contracted through civilian health facilities). TRICARE is the health plan that incorporates the two components, direct care and purchased care. In 2009, 23% of inpatient

care and 46% of outpatient care were delivered in military medical facilities. The rest was purchased in the private sector. $14.6 billion of the FY 2010 Defense Health Program (DHP) budget was for private sector care (Hunter, 2010).

TRICARE offers three general options for DOD beneficiaries: managed care options (TRICARE Prime, TRICARE Prime Remote, TRICARE Prime Overseas, TRICARE Prime Remote Overseas, US Family Health Plan), fee for service options (TRICARE Standard, TRICARE Standard Overseas, TRICARE Extra) and a Medicare wraparound coverage (TRICARE for Life) (TRICARE Management Activity, 2012). For the managed care options, most fall under the umbrella of TRICARE Prime, a health maintenance organization (HMO) option where enrollees are assigned primary care providers (PCP) who manage their care. It is the only group of options where beneficiaries must enroll. Under TRICARE Prime, enrollees may choose a military facility PCP or a network PCP (TRICARE Management Activity, 2012). For the fee for service options, beneficiaries may see any TRICARE-authorized provider for care. By using preferred network providers, beneficiaries utilize TRICARE Extra which provides beneficiaries a 5% discount on coinsurance, usually based on negotiated rates instead of the TRICARE maximum allowable charge under TRICARE Standard (TRICARE Management Activity, 2011-a).

For seniors 65 years old and over, in order to take advantage of TRICARE for Life, they must be enrolled in Medicare Parts A and B, and TRICARE becomes a wrap around supplemental insurance for Medicare. Medicare is the primary payer, and TRICARE is the secondary payer in most situations in the United States (TRICARE Management Activity, 2012).

All active duty personnel are automatically enrolled in TRICARE Prime at the military facility closest to the unit to which they are assigned. Active duty family members and retirees

and their family members under 65 years have the choice of the managed care or fee-for-service options. Of the 9.7 million DOD beneficiaries, 5.6 million were enrolled in TRICARE Prime, and 2 million were enrolled in TRICARE for Life, the option for beneficiaries 65 years and older. Beneficiaries choosing not to enroll, 2.1 million beneficiaries, default to TRICARE Standard (TRICARE Management Activity, 2011-c). Over 65% of beneficiaries with a choice (non-active duty and below 65 years of age) selected enrollment in TRICARE Prime in 2011 (TRICARE Management Activity, 2011-c).

The United States is divided into three TRICARE regions: North, South, and West. A separate TRICARE contractor for each of the three regions coordinates all purchased care unavailable at each military facility due to lack of capacity or lack of service mix. In addition, beneficiaries who elect TRICARE Extra or Standard receive purchased care regardless of what is available in military medical facilities. In the direct care system of the MHS, there are 59 military hospitals offering inpatient care in 2010 (Hunter, 2010). Many military hospitals are closing or changing to outpatient facilities. From FY 2001 to FY 2006, the number of military organizations operating inpatient facilities decreased from 77 to 67. The difference from 2006 to 2010 (67 to 59 inpatient facilities) reflects the additional eight military hospitals that have closed or stopped offering inpatient services during that time. The military health system parallels the civilian healthcare trend toward more outpatient care and less inpatient care.

In 2006, there were 25 teaching hospitals, which vary greatly in capabilities and size. In order to categorize them more uniformly, teaching hospitals were split into major teaching and minor teaching hospitals, a common categorization of teaching status (Landon et al., 2006; Vartak, Ward & Vaughn, 2008). Studies differentiate major vs. minor teaching hospitals by whether the hospital is a member of the Council of Teaching Hospitals and Health Systems

(COTH), but none of the military hospitals are members of COTH (Association of American Medical Colleges, 2005). Since one of the criteria for membership in COTH is participating in at least four residency programs (Association of American Medical Colleges, 2011), military hospitals having four or more residency programs according to the Accreditation Council for Graduate Medical Education (ACGME) were designated as major teaching hospitals for this study (ACGME, 2007). Major teaching hospitals are academic medical centers offering tertiary care and generally have more than 150 beds (Army Medicine, 2006). Non-teaching hospitals are community hospitals providing secondary care and usually have fewer than 150 beds. Minor teaching hospitals are generally community hospitals that provide some graduate medical education. Table 1 provides a summary listing of military hospitals by type and service over the six years of this study from FY 2001 to FY 2006. The ten major teaching hospitals are constant over time except for one Air Force hospital that changed to a minor teaching hospital in 2006. One Air Force hospital also changed from minor teaching to non-teaching in 2001. These hospitals were classified as major teaching and non-teaching, respectively, since that was their status for five out of the six years.

As can be seen in Table 1, most of the hospitals that stopped providing inpatient services were non-teaching and overseas hospitals. The healthcare industry trend toward decreasing hospitalizations and inpatient care is mirrored in the military setting. In order to minimize cost, some military hospitals outsource inpatient care to local civilian medical centers and become super clinics or ambulatory surgery centers. Increasing numbers of traditional surgeries and medical care that required hospitalizations in the past can now be performed in the outpatient setting or through home health care.

Table 1
Types of Military Hospitals by Service over Time

		2001	2002	2003	2004	2005	2006
Major Teaching	Army	5	5	5	5	5	5
	Air Force	2	2	2	2	2	2
	Navy	3	3	3	3	3	3
Minor Teaching	Army	6	6	6	6	6	6
	Air Force	4	4	4	4	4	4
	Navy	5	5	5	5	5	5
Non-Teaching	Army	13	13	13	13	12	12
	Air Force	12	11	11	9	9	6
	Navy	7	7	6	6	6	6
Overseas	Army	4	4	4	4	4	4
	Air Force	7	7	7	7	7	6
	Navy	9	9	9	9	8	8
	Total DOD	77	76	75	73	71	67

Wars in Iraq and Afghanistan

Operation Iraqi Freedom (OIF) had a force structure of 17 brigades and three division headquarters. Operation Enduring Freedom (OEF) (Afghanistan) had a force structure of three brigades and one division headquarters (Department of Defense, 2004). The bulk of the troops deployed since the end of combat operations in May 2003 are Army personnel. In general, Army troop rotations last 12 months and Marine troop rotations last seven months (Johnson & Tan, 2007). Ground troop rotation for OIF and OEF will impact productivity for the military hospitals. The Navy provides medical support for the Marine Corps. The Air Force deploys as Expeditionary Medical Groups to staff theater hospitals in Balad Air Base, Iraq and Bagram Air Base, Afghanistan. They also support the war with mobile aeromedical staging facilities, mobile

surgical teams and critical care air transportation teams that manage critically injured patients during aeromedical evacuations. Typically, Air Force troop deployments last four or six months (Svan, 2010). Therefore, differences across the three branches of service (Army, Navy, Air Force) in how long personnel are deployed and away from their usual workplace may have an influence on productivity and quality due to skill degeneration and reintegration issues such as physical and mental concerns.

In the beginning of the war in Iraq, a large portion of medical staff that deployed with operational forces tended to come from the same base. For example, when the 4th Infantry Division at Fort Hood, Texas deployed to Iraq in 2003, many of the medical personnel from Darnall Army Medical Center at Fort Hood were attached to those units. In the Navy, the deploying medical facilities (fleet hospitals, expeditionary medical facilities) were staffed primarily by one hospital (e.g., Pensacola Naval Hospital in Florida deployed 200 of the 300 medical personnel for Fleet Hospital 3 in 2003) (Bloom & Duren, 2003). For the Army, this policy of distributing deploying unit medical vacancies to "the local MTF closest to the gaining unit to the maximum extent possible" (Department of the Army, 1995, p. 6) was changed to the Regional Medical Commands in the update to the Army Regulation in 2007. The change in policy mitigated the stress on specific hospitals and cast a wider net for available medical personnel for deployment assignments.

Some of the uncertainty that the hospitals must deal with depends on which units deploy. In 2003, hospitals located in Fort Bragg, Fort Stewart, Fort Hood, Fort Campbell and Camp Pendleton would have experienced increased workload from mobilized reservists and pre-deployment processing for the major divisions and regiments preparing to deploy to the Persian Gulf (Department of Defense, 2003). The hospitals located in these bases would have

experienced some productivity decreases as facilities attempt to quickly replace and train personnel (O'Brien-Pallas et al., 2006) and probably some corresponding increases in purchased care to compensate for loss of internal capacity as hospitals adjusted to these changes. As the war has progressed, the military, including the medical community, has transformed into a more modular, mobile force. The Army deploys its forces as brigade sized elements, the brigade combat team, instead of divisions. The medical community has also changed to global sourcing for operational deployments so that the impact of deployment is spread out through many hospitals. The impact of the war on each medical center and hospitals' productivity and quality is likely to differ based on the number of full time equivalent (FTE) staff members deployed to provide medical support for combat operations or rerouted to support deployment operations at home station.

As soldiers were wounded in Iraq and Afghanistan, they were treated in the theater of operations by Army combat support hospitals, Navy fleet hospitals and Air Force theater hospitals. Those who needed more specialized care or needed longer recovery time were evacuated mostly to Landstuhl Regional Medical Center in Germany (Tanielian & Jaycox, 2008). Once evacuees were stable enough for travel to the United States, the Deployed Warrior Medical Management Center at Landstuhl coordinated patient movement to stateside military and veterans administration hospitals based on bed status, patient needs and available transportation. For example, wounded soldiers with burns were evacuated to Brooke Army Medical Center in San Antonio, Texas to the DOD Burn Center (Kauvar, Wolf, Wade, Cancio, Renz, & Holcomb, 2006). Many extensively wounded soldiers and marines were sent to major teaching facilities with robust medical capabilities. Although many were treated as inpatients, even more had to be processed and cared for in an outpatient status (Montgomery, Swiecki, &

Shriver, 2005). Taking care of soldiers who need many nursing care hours would take away focus from other patients.

Hoge (2006) and colleagues reviewed all post deployment health assessments from May 2003 through April 2004 to determine that 28.4% and 4.3% of returning personnel from Iraq were referred for medical follow-up and mental health problems, respectively. Post deployment increases in workload for military hospitals are especially high for mental health services. Although only 4.3% of personnel deployed to Iraq were identified for mental health care immediately after deployment, 35% of personnel actually used mental health services in the first year following deployment (Hoge, Auchterlonie, & Milliken, 2006). Similarly, Seal and colleagues (2009) found that 36.9% of veterans of the wars in Iraq and Afghanistan accessing clinical care in the Veterans Health Administration (VA) by the end of March 2008 had new mental health diagnoses. They found that the fastest growing prevalence was Post Traumatic Stress Disorder (PTSD) diagnosis followed by depression diagnosis, and 29% of new veterans had at least two comorbid mental health diagnoses. For soldiers surveyed using the PTSD Checklist (PCL), insomnia was the most commonly reported symptom immediately post deployment for soldiers who eventually were diagnosed with PTSD three months post deployment (McLay et al., 2010). PTSD in both Vietnam veterans and OIF/OEF veterans are likely to experience lower quality of life as evinced by poorer functioning and lower objective living conditions and satisfaction (Schnurr et al., 2009).

Bliese (2007) and colleagues assessed the timing of mental health assessments for service members returning from combat and peacekeeping operations. The authors found that soldiers were more than twice as likely to report mental health concerns during screenings 120 days following deployment rather than seven days (immediately) after deployment. Such evidence

led to the DOD implementation of the Post Deployment Health Reassessment three to six months after return from combat in addition to the initial screening during reintegration for comprehensive identification of service members needing deployment related mental health care. Thomas (2010) and colleagues also added support for later care seeking behavior by noting that prevalence rates increased 12 months after deployment when compared to three months after deployment. They also found that depending on the definition of a case for PTSD (level of functional impairment), the prevalence rates varied widely, ranging from 9% to 31%. In their review of PTSD, Kok (2012) and colleagues found evidence for differing risk for PTSD by branch of service. Army and Marine soldiers tend to have higher rates of PTSD when compared to their Navy and Air Force counterparts.

Another factor that may play into the identification of service members who need mental health care is the issue of anonymity. Although the stigma associated with mental health issues in the military has decreased, there is still perception that mental health injuries are less valid than physical injuries (Wright et al., 2009). Warner (2011) and colleagues noted in their study that with an anonymous survey, Army soldiers were more than twice as likely to report mental health problems (depression, PTSD, suicidal ideation) than on the concurrent Post Deployment Health Assessment. In the anonymous survey, 12.1% of the respondents met criteria for PTSD or depression, but only 4.2% of the soldiers completing the Post Deployment Health Assessment met the criteria for PTSD or depression.

Deployed health care workers are exposed to many of the same environmental conditions as combat troops, and they may develop post traumatic stress disorder (PTDS) and depression once they return from deployment. Grieger and colleagues (2007) studied risk factors for developing PTSD in healthcare workers who had deployed to Iraq and Afghanistan. They found

that exposure to wounded and dead patients did not increase the risk for PTSD, but personal threat of harm was a risk factor for PTSD. The study was only conducted at one navy medical center, however, and the results may not be generalizable to all military healthcare workers.

In a review of the literature, Gibbons, Hickling, & Watts (2012) concluded that deployed healthcare providers have increased probability of psychological disorders due to traumatic events. One of the limitations of their study was the predominance of the reviewed research was on Vietnam era nurses. They noted a gap in the literature of traumatic stress on healthcare professionals who served during the wars in Iraq and Afghanistan. They also noted the need for research on functional impact of combat exposure, especially how deployed healthcare providers seek mental health care as well as their beliefs about utilization of such services. Although not stated explicitly by Gibbons and colleagues, another important aspect of the functional impact is how traumatic stress may manifest in job performance and coping strategies of reintegrated healthcare providers, thereby influencing productivity and quality of military hospitals.

Another factor that military healthcare professionals may struggle with is compassion fatigue. Compassion fatigue, a form of secondary traumatic stress, may also affect military hospital workers who have not been deployed but have to treat patients who have been extensively wounded by the conflicts in Iraq and Afghanistan. Hagerty and colleagues (2011) identified the situations that generated stress in Army, Navy, and Air Force nurses caring for wounded service members were “deployment, fatigue, heavy workload, and anguish involved in caring for patients with severe physical and emotional trauma” (p. 88). In their qualitative phenomenological study, there was a mix of nurses who had deployed as well as nurses who had not deployed. Healthcare professionals may self treat to avoid the stigma associated with seeking help for psychological disorders which may damage their careers. When the Army

instituted a policy to limit medical deployment augmentee assignments to 180-day rotations in January 2008, they cited degradation of complex medical skills and compassion fatigue as reasons for shortening deployment length for physicians, dentists and nurses (Office of the Surgeon General, 2008).

There has been descriptive research about the types of war injuries (Cancio et al., 2005; Fox et al., 2005; Zouris, Walker, Dye & Galarneau, 2006), experiences of deployed medical units (Murray et al., 2005), mental health prevalence and utilization following deployment (Hoge, Auchterlonie, & Milliken, 2006; Hoge et al., 2004; Erbes, et al., 2007; Thomas et al., 2010; Kok et al., 2012), disease and nonbattle injury admission rates (Wojcik et al., 2008), defining measures for wounded to killed ratio (Goldberg, 2010), and experiences at one or two medical center (Montgomery, Swiecki & Shriver, 2005; Tentua, 2006; Kenny & Hull, 2008). The majority of the research about the wars in Iraq and Afghanistan has focused on mental health of service members and family members during and post deployment, especially PTSD and mild traumatic brain injury (Felker et al., 2008; Monson, et al., 2009; Seal et al., 2009; Schnurr et al., 2009; Warner et al., 2011; McLay et al., 2010) Few researchers focused on the healthcare providers, whether deployed or in fixed facilities (Hagerty et al., 2011; Gibbons, Hickling, & Watts, 2012; Grieger et al., 2007). However, there are no studies examining the performance of all MHS hospitals at the organizational level during a time of war, and whether and how they have adapted performance to the prolonged war.

War -- An Environmental Jolt

Military leaders should have foreseen that deployments to the Middle East would increase as events escalated with Saddam Hussein in late 2002 and early 2003. However, the White House, Pentagon officials, and the military forces were not properly sized and resourced

for the consequences of the invasion of Iraq in March 2003, especially the duration and nature of the fighting in Iraq and Afghanistan since then (Tanelian & Jaycox, 2010). The intent of the invasion was to liberate the Iraqi people from Hussein, not to occupy the country once the regime fell. Although the military prepares for war and has contingencies in place for fighting wars, the extent of security and stability operations required in Iraq surprised many in the military as well as the nation as a whole. In addition, each military hospital would not know how much the organization would be affected until unit deployment orders were issued.

The wars in Iraq and Afghanistan could be classified as an “environmental jolt” for military hospitals. Meyer (1982) defined environmental jolts as “transient perturbations whose occurrences are difficult to foresee and whose impacts on organizations are disruptive and potentially inimical” (p. 515). The loss of staff to deployment operations and increased, unpredictable workload due to injured service members may be quite disruptive for many hospitals. The quick end to the prior major war effort in the Middle East (Operation Desert Shield/Storm, August 1990 to March 1991) may have lulled some military and civilian leaders into preparing for a much shorter, more limited disturbance. The wars in Iraq and Afghanistan have had direct impact on military hospitals through deployment of personnel and increased workload complexity.

Productivity

From FY 2001 to FY 2006, purchased care costs increased 19.6% per year (Lurie, 2008). The MHS leadership focused on recapturing some of the workload back into the military treatment facility. From the years 2004-2010, care purchased in the TRICARE network has steadily increased while care provided in military hospitals has decreased or remained constant (Military Health System, 2012, p. 34). According to the Congressional Budget Office (2011),

DOD's growth in spending per capita outpaced the national average (5.9% and 4.8% per year – purchased care and direct care, respectively – versus 1.7% per year).

One way of increasing productivity is by changing the funding mechanism for budgets in the MHS. The Assistant Secretary of Defense (Health Affairs) allocates funds to the medical departments of each service--Army, Navy, and Air Force. The services then allocate funds down to each hospital. Traditionally, hospitals within the MHS have been funded based on historical staffing and supply budgets, which did not take into consideration changes in mission or changes in enrollment populations that would impact the amount of services rendered. As missions and enrollment changes occur, medical facilities respond by increasing or decreasing staffing to take care of the beneficiaries, and as long as the workload produced justifies the increased staffing, the facilities obtain the increased funding in the new system. "Health Affairs [Office of the Assistant Secretary of Defense (Health Affairs)] continues to budget the military services at the macro-level for health care, and directed the services to increase productivity by increasing inpatient relative weighted product (RWP) and outpatient relative value units (RVU). Provider productivity, whether increased or decreased, will guide budget adjustments within each service" (Kiley, 2006, p. 1).

Performance may be conceptualized as a combination of productivity and quality, but military hospitals usually evaluate quality and productivity separately. Ozcan (2008) defines performance as "an appropriate combination of efficiency and effectiveness" (p. 4). He states that in the performance literature, efficiency and productivity are used interchangeably. Longest (1977) defines productivity as "the ratio of value of services produced (output) to the value of the factors that have contributed to their production (inputs)" (p. 476). Productivity is generally defined as the ratio of output to input (Ozcan, 2008; Rogers, 1998). There is a positive

association between productivity and formalization in the form of clear policies and guidelines (Glisson and Martin, 1980).

AHRQ (2008) sponsored a systematic review of measures for efficiency in healthcare, conducted by the RAND Corporation, and found that depending on the stakeholder, the meaning of the word “efficiency” changed. In the report, “efficiency” was defined as “the relationship between a specific product (output) of the health care system and the resources (inputs) used to create the product” (AHRQ, 2008, p.13). The AHRQ report definition of efficiency aligns to some of the definitions of productivity in the previously referenced literature.

In the economic literature, productivity, the rate at which goods or services are produced, is directly affected by efficiency. Efficiency is defined as “using the minimum number of inputs for a given number of outputs” (Ozcan, 2008, p. 4). With the increasing pressure to reduce costs and increase productivity, there have been many research endeavors in the health care sector on cost efficiency (Hollingsworth, 2003; Worthington, 2004; Laine et al., 2005; Fulton et al., 2008; Fulton et al., 2007; Hollingsworth, 2008). Hollingsworth (2008) conducted a review of health care productivity and efficiency, and he notes that the economic definition of technical efficiency that is used in most studies is only a partial measure of overall performance.

One method of measuring efficiency is data envelopment analysis (DEA). In the review of the literature by Hollingsworth (2008), over 60% of the studies used DEA, either solely or in conjunction with regression. The AHRQ (2008) report also found that DEA was one of the predominant methodologies used in the peer reviewed literature about healthcare efficiency. DEA has been used to assess efficiency and quality (Clement et al., 2008; Valdmanis et al., 2008; Fulton et al., 2008). Clement and colleagues (2008) and Valdmanis and colleagues (2008) utilized AHRQ quality indicators, IQIs and PSIs respectively, as a measure of quality within the

DEA model. Fulton and colleagues (2008) also used DEA to calculate an efficiency variable in order to model Army hospital cost as a function of workload, patient population, quality, access, and efficiency. DEA utilizes multifactor productivity, the ratio of output to all associated inputs. However, DEA is based on relative rankings within a group, and the choice of inputs and outputs as well as peer groups change the efficiency score for facilities. It is also a measure that military hospitals cannot readily compute in order to monitor their performance because the information and software required are not readily available at each hospital level. In order to compare hospitals as decision making units (the level of analysis for DEA), data must be collected at the military service or DOD level. Partial productivity, the ratio of output to one input (e.g., visits per physician), is a simpler measure of efficiency, but it does not capture the complexities of hospital care. Although some studies use other simpler measures for efficiency, such as length of stay, there is no consensus within the health care industry about what components should be included in the measurement of efficiency (AHRQ, 2008). The AHRQ report identified seven approaches to efficiency measurement in the literature and corresponding metrics for each approach that met their definition of efficiency. The seven metrics are: cost per episode, cost per discharge, cost per covered life, cost per health improvement, labor utilization, productivity, and generic prescribing rate (AHRQ, 2008, p. 22). The objective of using the productivity metric was to maximize output; however, the AHRQ definition of productivity only applies to physician productivity. Hospital productivity is categorized as "labor utilization" and most of the hospital literature used discharges or inpatient days as output (AHRQ, 2008). Since funding for hospitals in the MHS is based in part on productivity, this research used productivity instead of cost related efficiency measures in defining organizational performance.

For military hospitals, productivity has been studied more in the outpatient setting (physician productivity) versus the inpatient setting. Aiello (2005) conducted a productivity analysis for various outpatient surgical services at one military medical center in order to compare the productivity results with Medical Group Management Association standards. She used workload (outpatient visits + ambulatory procedure visits) divided by FTEs. Only one service, Ophthalmology, outperformed the civilian sector in an academic setting at the 90^{th} percentile.

The RWP is a weighted workload measure reflecting case complexity and resource use for inpatient care. TRICARE/Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) Diagnosis Related Group (DRG) weights are used to compute RWPs for military hospitals. TRICARE DRG system is modeled on the Medicare Prospective Payment System (PPS). Each year as Medicare PPS changes are made and published in the Federal Register, TRICARE DRG is updated (Federal Register, 2010). For Medicare PPS, each DRG is assigned a payment weight based on the average resources used to treat Medicare patients in that DRG. The TRICARE DRG is modified slightly based on the average resource utilization for the population of hospitals submitting claims to TRICARE. For DRG 107, coronary bypass with catheterization, in FY 2005, Medicare PPS DRG weight was 5.3757 and the TRICARE DRG weight was 5.4261 (TRICARE, 2010; Centers for Medicare and Medicaid Services (CMS), 2010). With TRICARE DRG weights as the base, adjustments are made based on the patient's source of admission, length of stay, and discharge status. For example, outlier thresholds for DRG 107, coronary bypass with catheterization, is 3 and 25 days for FY 2005 (TRICARE, 2008-b). A discharge with any length of stay within that range will receive the base RWP of 5.4261, the TRICARE DRG weight for DRG 107. Lengths of stay outside of that range, shorter or

longer, will have adjustments made to the base RWP (Coventry et al., 1995). The number of RWPs (weighted discharges) is an appropriate productivity measure for military hospitals because it has face validity. During the 2011 MHS Conference, Captain Atkinson briefed that the prevailing MHS pay for performance system aimed to maximize workload with a focus on productivity or outputs--"the volume of work that we accomplish, measured currently by RVUs/APCs and RWPs/Bed Days" (Atkinson, 2011, Slide 16). It is how the Assistant Secretary of Defense (Health Affairs) defines productivity for inpatient services (except mental health services which are measured in bed days), and military hospitals receive financial bonuses for increasing RWPs relative to their baseline (Kiley, 2006). However, productivity is but one aspect of performance, and the MHS is transitioning to a value based pay for performance system incorporating outcomes and patient satisfaction (Atkinson, 2011). The quality of care, in both process and outcome, is an important aspect to measure to determine overall hospital performance.

Quality

As far back as Donabedian in the 1960s, researchers have attempted to define and evaluate quality. With the advances in information technology (e.g., electronic health records, electronic claims submissions, electronic decision support and reminder systems), use of quality information for contracting and public reporting has become more mainstream. A key aspect of hospital performance is quality. The Institute of Medicine (IOM) defined quality as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (Institute of Medicine, 1990, p. 21). With the rise of consumer report cards and public reporting of quality data, organizations

must focus on documenting the quality rendered in their facilities in order to survive in the competitive health care sector.

According to the IOM report, *To Err is Human: Building a Safer Health System* (1999), three domains of quality are safety, provision of care following evidence-based medical standards, and customization to the needs of the individual. The IOM defines a preventable adverse event as "an injury caused by medical management rather than the underlying condition of the patient … attributable to error" (Institute of Medicine, 1999, p. 28). Preventable adverse events undermine the trust and confidence of patients in the health care system, and hospitals' emphasis on safety would create an environment that reduces error and adverse events. Quality measurement in military hospitals generally focuses on the first two domains of quality.

Alonso and colleagues (2006) describe the development of Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS), a collaborative effort between the DOD's Patient Safety Program and the Agency for Healthcare Research and Quality. TeamSTEPPS is an initiative to reduce medical error through a program of team training. The precursors to TeamSTEPPS were MedTeams in the Army and Navy and Medical Team Management in the Air Force, both based on Crew Resource Management training from aviation. Morey and colleagues (2002) conducted a prospective quasi-experimental evaluation of MedTeams using nine hospital emergency departments. They found that, in the experimental group, the overall quality of teamwork and staff attitude toward teamwork increased while observed clinical errors decreased. The Air Force needed a separate program due to cultural and structural differences in Air Force hospitals. MedTeams and Medical Team Management training was implemented in the MHS from 2001 to 2003, but after program evaluations, the TRICARE Management Activity developed and implemented TeamSTEPPS for a unified,

standardized training program to increase patient safety. By 2006, 25 inpatient and outpatient facilities had implemented TeamSTEPPS in the MHS (Alonso et al., 2006). TeamSTEPPS is a three phase teamwork system designed for creating a culture of safety in healthcare settings, and it is now being implemented nationally with six civilian Team Resource Centers throughout the United States (AHRQ, 2012).

The MHS has traditionally measured quality as part of organizational quality improvement. There are several studies of quality in military hospitals. Some studies measure quality by type of medical care with a focus on global, MHS-wide issues of quality. Linton and Peterson (2004) studied whether the presence of certain chronic conditions before pregnancy may increase the likelihood that a woman will deliver by cesarean section in military hospitals. They found that patients with diabetes, genital herpes, and hypertension were more likely to deliver by cesarean section, and even after adjusting for these chronic diseases, there were differences in observed cesarean section rates for black and Asian women when compared to white women.

Some studies are specific to one hospital. Oliver and colleagues (1999) evaluated the establishment of an infusion service at one military hospital to ease patient and provider frustration. They found that length of stay for organ transplant patients decreased, and staff productivity in the dialysis clinic increased. Scheirman (2001) studied medication errors at a military academic medical center to identify root causes, an area not widely studied according to the IOM report, *To Err is Human*. She found that ordering and transcription processes accounted for 65% of all medication errors reviewed for the year 2000, and she recommended actions that could be implemented easily in the short-term to address root problems. Olsen and Coleman (2001) studied 30-day readmission rates at one military medical center to identify high risk

factors. They found that patients with chronic illness and patients over 65 years old were more likely to be readmitted. These studies of single military hospitals may be specific to the individual hospitals studied and not generalizable to the whole population of military hospitals.

Few studies tackle the issue from an organizational quality viewpoint. Linton and colleagues (2005) studied variations in cesarean section rates in military hospitals to determine whether the variations were due to differences in clinical case mix. They found that observed cesarean section rates were higher than predicted rates for small hospitals and teaching hospitals after accounting for case mix. Beauvais and colleagues (2007) used military treatment facility fiscal margin to predict quality (patient satisfaction) from the Consumer Assessment of Health Plan Satisfaction (CAHPS). They found a positive association between organizational financial strength and quality outcomes. Thus, very few studies address organizational quality in military hospitals, and there are none that address the effects of the war on military hospital quality.

Outside of the MHS, published studies of quality are plentiful. Much work has been done in the measurement of quality in recent years. CMS launched *Hospital Compare*, a website that publicly displays rates for recommended process of care measures for certain types of patient conditions (e.g., heart attack, heart failure, pneumonia). The website also displays a few outcome measures such as 30 day risk adjusted mortality rates and readmission rates (CMS, 2011). Werner, Bradlow & Asch (2008) assessed whether the process measures reported on Hospital Compare directly increase outcomes or whether they were a proxy for unmeasured aspects of quality care. Hospitals were divided into groups performing at the 75th percentile in process measures versus hospitals performing at the 25th percentile. By comparing observed hospital mortality rates to expected mortality rates derived from randomized controlled studies and previous literature, they concluded that the difference in observed to expected mortality rates

was too big for the process measures to only account for the direct relationship. They concluded that there were unmeasured aspects of quality care that adherence to process of care measurements alone could not account for in the outcome.

In a qualitative study, Curry and colleagues (2011) examined hospital factors that differentiated the top 5% versus bottom 5% of performers in 30-day risk standardized AMI mortality rates as reported in Hospital Compare. They identified six domains: hospital protocols and practices, organizational values and goals; senior management involvement, broad staff presence and expertise, communication and coordination, and problem solving and learning. Of these six domains, high performers differed from low performers in all but the domain of hospital protocols and practices. The high performing hospitals differed from low performing hospitals in that they had: a) a shared vision of excellence; b) senior management was committed to high quality AMI care by providing financial resources as well as openly tracking quality performance using data; c) physician champions were involved in quality improvement and expertise of nurses and pharmacists were used to the fullest extent; d) effective communication and coordination of transitions of care were evident; and e) organizational culture valued innovation and learning. This qualitative study highlights the importance of supportive organizational culture in improving quality in addition to the implementation of protocols and performance improvement practices.

The Agency for Healthcare Research and Quality (AHRQ) created quality indicators (QI) using readily available hospital administrative data to "highlight potential quality concerns, identify areas that need further study and investigation, and track changes over time" (AHRQ, 2006-b). AHRQ QIs represent well established measures that have been used in many quality studies (Romano, Geppert, Davies, Miller, Elixhauser, & McDonald, 2003; Rivard, Rosen, &

Carroll, 2006; Rivard, Elixhouser, Christiansen, Zhao & Rosen, 2010; Vartak, Ward & Vaughn, 2008; Borzecki et al., 2010). Organizations may use the AHRQ QI software with their own inpatient data to assess and monitor inpatient quality performance.

The AHRQ quality indicators have also been applied to international healthcare organizations. Drosler and colleagues (2009) found that patient safety indicators (PSI) may be applied to hospital data from multiple countries. They emphasized the importance of validation using medical records because it was difficult to tell whether the variation was true variation in errors or whether the observed variation was due to variation in coding. They also found that the countries with no financial incentive for accurate coding had the highest variation in PSI rates. These measures are not perfect, but they are much better than what was previously available. This study uses AHRQ QI software with MHS inpatient data to assess quality.

Prior research has identified a number of hospital characteristics associated with higher quality, especially teaching status. Landon and colleagues (2006) found that major teaching hospitals performed well in treatment and diagnosis quality indicators, but they performed poorly in counseling and prevention indicators. Allison and colleagues (2000) studied whether a hospital's teaching status was associated with quality of care and mortality for Medicare patients with acute myocardial infarction. They found that major teaching hospitals had better quality in three of the four indicators as well as lower mortality rates than minor and non-teaching hospitals. Jha and colleagues (2005) also found that teaching status was associated with higher rank in AMI and congestive heart failure performance, but lower rank in pneumonia performance. Vartak and colleagues (2008) also found mixed evidence regarding teaching status. Major teaching hospitals, when compared to minor and non-teaching hospitals, had higher PSI rates for postoperative pulmonary embolism / deep vein thrombosis and postoperative

sepsis while having lower rates of postoperative respiratory failure. Romano and colleagues (2003) found that urban teaching hospitals had the highest incidence of patient safety events but the lowest incidence of anesthesia reactions and complications, postoperative hip fracture, and birth trauma.

Summary

In summary, military hospitals experienced an environmental jolt with the events following the terrorist attacks on September 11, 2001. Operation Enduring Freedom in Afghanistan closely followed by Operation Iraqi Freedom has meant that the military is on a war footing. There are few studies of military hospitals during wartime. Most studies focused on mental health prevalence and utilization (Hoge, Auchterlonie, & Milliken, 2006; Tenelian & Jaycox, 2008; Hoge et al., 2004; Erbes, et al., 2007; Thomas et al., 2010; Heltemes et al., 2011; Kok et al., 2012; Seal et al., 2009) and types and epidemiology of war injuries treated (Cancio et al., 2005; Fox et al., 2005; Zouris, Walker, Dye & Galarneau, 2006, White, et al., 2011). Although the literature review identified many studies studying efficiency, productivity and quality in civilian hospitals, there is limited research into the same subjects in military hospitals. In addition, the author has not been able to identify any study examining quality and productivity of all military hospitals during a time of war. Chapter 3 presents the theoretical framework underlying the development of the hypotheses to analyze the impact of war on the productivity and quality of permanent military hospitals that must juggle both peacetime and wartime missions.

Chapter 3: Theoretical Framework

Contingency theory helps to frame the issues surrounding organizational response to the adaptation of military hospitals to the jolt of war. The development of the conceptual model stems from the different aspects of performance in the hospital sector. The increasing emphasis on measurement of outcomes in hospitals to track its performance may shed light on the context of structural adaptation to ensure organizational fit with the contingency environment. Uncertainty created by the jolt of the wars in Iraq and Afghanistan may lead to predicting organizational response. Contingency theory is applied to develop a conceptual model that differentiates among organizational characteristics of military hospitals during a time of war.

Contingency Theory

According to Contingency Theory, "there is no one best organizational form but many, and their suitability is determined by the goodness of fit between organizational form and environment" (Scott, 2003, p. 105). Organizations that have the best fit with their environment will be most effective and will achieve the best adaptation, thereby enhancing organizational effectiveness.

In order to achieve the best fit, contingency factors must align with organizational structure (Donaldson, 2001). Donaldson (2001) defined contingency as "any variable that moderates the effect of an organizational characteristic on organizational performance" (p. 7). Contingencies identified in the literature are environment, size and technology (Donaldson, 1987; Child, 1972; Child, 1975). The fit between contingency variables and organizational

structure affect performance, so that the extent to which levels of the organizational structure and the levels of the contingency match will determine how well organizations perform (Donaldson, 2001). Any change in the contingency variables exerts pressure for organizations to modify organizational structure in the long run because any misfit between the contingency variables and structure leads to lower performance (Donaldson, 1987; Donaldson, 2001; Child, 1972).

According to Tosi and Slocum (1984), the key constructs in contingency theory are effectiveness, environment, congruency, and structure. They state that many of the divergent findings in research utilizing contingency theory are due to lack of development of key concepts. They define effectiveness as "the degree to which an organization obtains a very limited number of highly desirable outcomes" (Tosi and Slocum, 1984, p. 12). The dimensions of environment are uncertainty and complexity. Congruency is the fit between the environment and the organizational structure, and it is the crux of contingency theory. "Improving congruency between the environment and the organization supposedly leads to increased effectiveness" (Tosi and Slocum, 1984, p. 15). Finally, the dimensions of organizational structure are formalization, centralization, and complexity.

Organizations must achieve a balance, or congruence, between the organization's external environment and internal strategies. Internal strategies may include possessing the appropriate technology at the appropriate time, maintaining and hiring appropriate skill levels of individuals and ensuring those individuals perform the right tasks at the right time. Donaldson (1987) formalized this theory and developed the structural adjustment to regain fit model (SARFIT), which holds that a change in contingency variables lead to "misfit" with the existing structure of the organization; the resulting incongruence leads to decreased performance, which signals to the organization that things must change and ultimately leads to organizational

structural adjustments to regain "fit" and eventually performance. While Donaldson stressed that structure needed to be changed to fit the changes in the contingency variables, Child emphasized that retaining the structure of the organization may be important enough to the dominant coalition that instead of changing the structure in situations of misfit, the reverse happens and the contingency variable is modified to match structure in the strategic choice model (Donaldson, 1987; Donaldson, 2001; Child, 1972).

The factors that explain the best organizational form are environmental complexity and uncertainty (Scott, 2003). Organizational form such as centralization/decentralization of decision making, informal/formal structure influence the fit with the environment. As complexity and uncertainty increase, smaller, decentralized and informal organizations are better able to adapt to rapid changes and fit better with the environment. Smaller organizations process information more quickly and can react faster than large, hierarchical organizations. Less complex organizations are more capable of innovation and success in unpredictable and turbulent environments. On the other hand, larger, centralized and formal organizations have the resources and structure to respond to foreseeable changes in the environment. As organizational size increases, a higher degree of routinization is required. Larger organizations with more diverse personnel with a variety of skill sets and larger administrative components are more able to handle predictable changes in the environment. Small organizations, however, are better able to deal with lack of perfect information. Smaller military hospitals tend to be non-teaching hospitals, and they may be more agile in changing organizational structure.

In relation to organizational size and organizational complexity, bigger and more complex organizations will take longer to reorganize and complete the changes necessary to regain fit with their environment (Hannan & Freeman, 1984). The complexity of military

hospitals differs depending on their size and the types of services offered. Military hospitals may be divided into three teaching status categories: major teaching hospitals, minor teaching hospitals, and non-teaching hospitals. For this study, major teaching hospitals are defined as hospitals with four or more medical residency training programs, and minor teaching hospitals have between one and three medical residency training programs. Major teaching hospitals have more operational beds and provide more medical and surgical subspecialty care. They also have more nursing specialty training and allied health training programs. Thus, size and teaching status is inextricably tied to complexity. Major teaching hospitals will adapt more slowly to regain fit after a jolt due to its complexity in service provision and size.

Previous studies have shown that graduate medical education programs will influence physician productivity (Linna, 1998; Johnson, Shah, Rechner, & King, 2008). "An indirect influence of teaching and research is the loss of labour [sic] productivity in patient care: students and research projects absorb the time of the professional personnel. The more students in relation to professionals, the more time for teaching is needed" (Linna, 1998, p. 419). Resident involvement significantly reduced physician productivity by almost 2500 RVUs in a year timeframe within a general internal medicine practice (Johnson, Shah, Rechner, & King, 2008). Major teaching hospitals with many graduate medical education programs will have lower productivity per FTE. They also receive most of the inpatient wounded personnel from the war due to their capabilities; therefore, the burden of caring for casualties returning from the war would fall mostly to major teaching hospitals. Since major teaching hospitals are larger and more complex, they would be less able to adapt to the environmental jolts of war.

The degree of formalization and centralization in all military hospitals is high. Rules and policies are formalized at all levels: hospital, military branch, and DOD/Assistant Secretary of

Defense (Health Affairs). Decisions such as converting to all outpatient services cannot be made at the hospital commander (chief executive officer) level. Adding services or capabilities such as a neonatal intensive care unit or inpatient psychiatric ward starts at the hospital level, but formal consent must be given by the Surgeon Generals of the respective military branch. Decisions to close or combine military hospitals at times must be approved by Congress. In the *Final Report to the President*, *Appendix Q: Commission's Final Recommendations*, the Defense Base Closure and Realignment Commission (2005) identified numerous hospitals that will either combine inpatient services with another military hospital (Walter Reed and Bethesda) or convert to an outpatient clinic (6^{th} Medical Group, McDill Air Force Base).

However, hospital commanders have control over some decisions that could significantly impact productivity and quality. While military medical personnel distribution is highly centralized and is determined at the military branch level, decision making authority for adding new civilian staff, major capital investment, and a host of other decisions (e.g., levels of management hierarchy, which disease and case management services to offer, contracts) are reserved for the hospital commander. For example, increasing government service civilian personnel or contract personnel is within the discretion of the hospital commander. Although specific hiring and firing decisions are typically delegated to lower level managers, the hospital commander is ultimately responsible for overall staffing.

Military hospitals will have variation in their structure based on their mission, teaching status, service affiliation and robustness of the civilian medical services in the local area. Larger medical centers will be slower to adapt their structure, and depending on the degree of formalization and centralization at each hospital, their organizational response to the

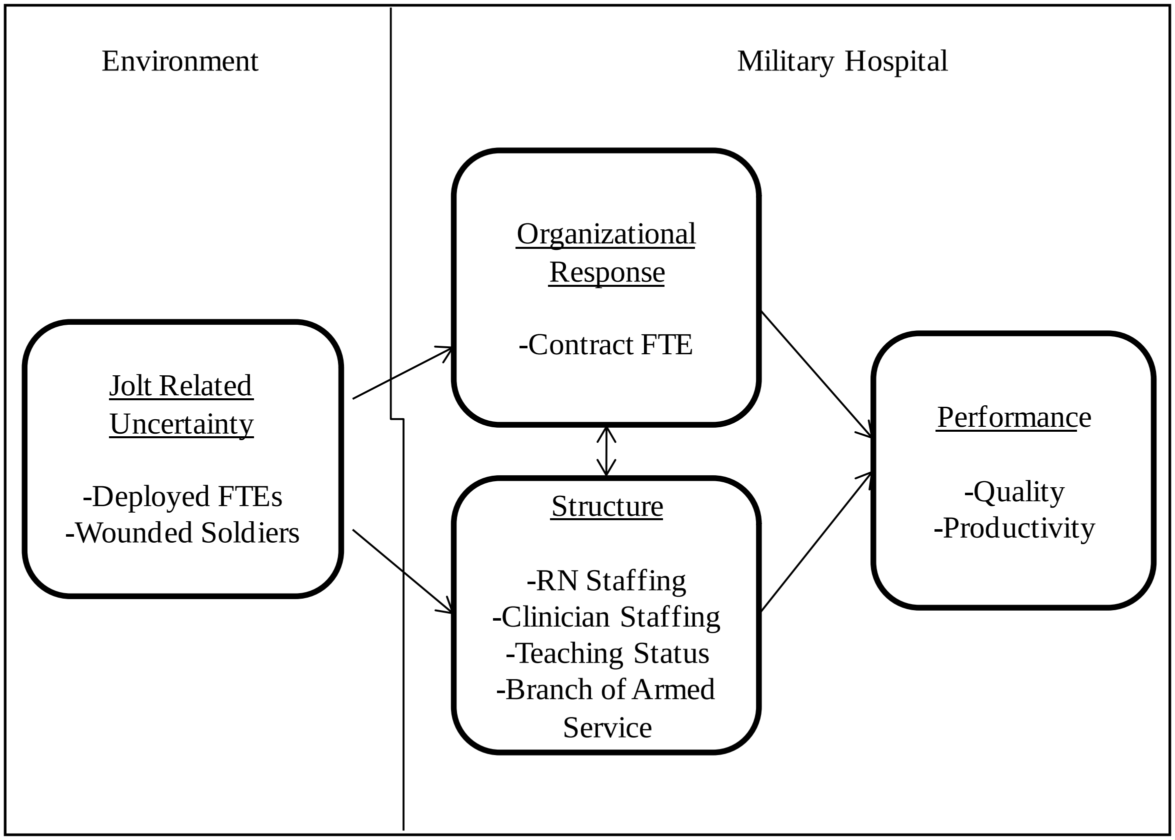
environmental jolt will likely to occur in modifications to civilian and contract staffing and modification of services provided.

Theoretical/Conceptual Model

Drawing on contingency theory, the conceptual model for the study is presented in Figure 1. The wars in Iraq and Afghanistan create an environmental jolt for military hospitals and create uncertainty. Uncertainty affects the ability of the organization to forecast and prepare for wounded soldiers who have extensive injuries that require resource heavy care (e.g., traumatic brain injury, amputations). Hospitals must contend with many factors when major units or mobile medical facilities deploy from the base. First, the hospital must contend with losing military staff and training new reservist backfill who may or may not match the skills of staff lost to deployment. Second, the hospital is responsible for pre-deployment medical processing of deploying soldiers to ensure their medical readiness including, for example, ordering 90-day supply of medications, running tests, checking for pregnancy and assessing mental stability. Third, each brigade that deploys takes away about 4,000 enrollees who would normally receive care at the medical facility. Finally, when the units return, the hospitals must conduct post-deployment medical processing, including referring soldiers and marines for mental health care due to post traumatic stress or for medical care due to injuries and problems during deployment.

In Figure 1, Deployed FTE is the percentage of staff time attributable to deployment or readiness activities such as pre and post deployment processing. The percentage of deployed FTEs along with the percent of wounded inpatients to the total inpatients reflects the jolt related uncertainty that the hospitals face because of the wars in Iraq and Afghanistan.

Figure 1. Conceptual Model of Military Hospital Performance Using Contingency Theory



The line in Figure 1 separates the environment from the organization (military hospital). The structure of the military hospitals may be characterized by nurse and clinician staffing. Workload is limited by clinician staff, nursing staff and available beds for inpatient hospitals. Teaching hospitals have different, more complex services and patients than regular community hospitals; therefore, teaching status is another measure that identifies the structure of the hospital. Due to the high correlation between bed size and teaching status, only teaching status is reflected in the conceptual model in Figure 1. The culture and mission of the hospitals differ based on the branch of armed service; hence, the services have differing organizational structures.

Military hospitals must hire new staff to cover the workload when staff are diverted to the readiness mission, and they also must train reservists who are activated to backfill some of the

military staff losses. Due to the high degree of formalization in military hospitals and in the MHS, there are limits to what the individual hospitals can control in terms of structure (e.g., increasing staff, building additions, and adding services). Hospitals essentially have two immediate organizational responses: hire contractors to replace deployed staff to keep services in the hospital or to allow care to be purchased in the surrounding hospitals. When making this decision, the hospital leadership may take into account the costs and benefits of contracting for personnel in their specific geographic area and labor market versus the capacity and capabilities of surrounding civilian hospitals. The costs and benefits evaluated include non-financial concerns, such as time involved in monitoring and enforcing contracts, as well as financial concerns. For example, if there is excess capacity in local civilian hospitals and the medical workforce in the area is not as robust, the hospital may choose to purchase care instead of trying to contract personnel. However, if there is little or no excess capacity or relatively unique medical services required by returning soldiers, the hospital may be forced to contract for personnel they can use to provide these services directly even if that would be more difficult to do. Finally, over time, hospitals have some ability to adjust their response and structure, given changes in deployments, wounded soldiers and based on information about its performance. As shown in Figure 1, the percentage of deployed staff and the percent of wounded soldiers subsequently affect the organizational response in determining the number of additional contract personnel hired.

The second immediate response of sending care out into the network, the amount of purchased care, may impact quality by providing a release valve for overwhelmed hospitals. However, the availability of medical evacuation assets within the Air Force makes it is more likely for inpatients, especially Active Duty personnel, to be sent to a different military hospital

beyond the local commuting area for care. Unlike outpatient care that has to be kept in the local area where the patient resides, inpatient care may be sent to a military hospital that either specializes in the care or has the capacity. After initial consideration, the amount of purchased care was eliminated as a possible variable due to the inability to attribute care purchased in a multi-service market area to a specific hospital. For example, Wilford Hall, an Air Force Hospital, and Brooke Army Medical Center are located in and share service to the San Antonio metropolitan area. It is impossible to determine whether the purchased inpatient care should have been serviced by Wilford Hall or Brooke Army Medical Center. Only the first organizational response of hiring contract personnel is kept in the model.

The fit between structure (and organizational response) and jolt related uncertainty should influence hospital performance in quality and productivity. The evidence of whether there is fit between the structure and the environment is the performance metrics of high production of RWPs (productivity) and low incidence of adverse events (quality). The hospitals will use feedback on performance to constantly strive to regain fit.

Hypotheses Development

Utilizing contingency theory as related to the study's conceptual model investigating the impact the jolt of war had on the military hospitals, this analysis addresses two research questions. First, how did productivity and quality change overall over the years 2001-2006 in military hospitals after the jolt of war? Essentially, what effect did the wars in Afghanistan and Iraq have on the performance of military hospitals as they responded to the jolt of war in the early years? Second, do productivity and quality trends differ over the years 2002-2006 by type of hospital?

Landon and colleagues (2006) found that teaching status is associated with higher quality in treatment of AMI but not CHF and pneumonia. Using factor analysis, they determined two underlying domains of quality across all three conditions: 1) treatment and diagnosis and 2) counseling and prevention. Major teaching hospitals performed well in the quality indicator domain of treatment and diagnosis, although they performed poorly in the quality indicator domain of counseling and prevention. Landon and colleagues used quality indicators that were reported to the Center for Medicare and Medicaid Services (Hospital Compare) and Joint Commission, not AHRQ quality indicators. Allison and colleagues (2000) also found that major teaching hospitals had lower mortality rates than minor and non-teaching hospitals in the treatment of acute myocardial infarction. They used actual mortality rates 30 days, 60 days, 90 days and two years post hospitalization, unlike the AHRQ IQI 15 which is the expected AMI mortality rate used for this study. In addition, Fine and colleagues (2002) identified teaching status to be positively associated with timely initial antibiotic administration in elderly patients with pneumonia. Studies have also shown a relationship between teaching status and quality utilizing PSIs (Rivard, et al., 2010; Vartak et al., 2008). Similar to Landon and colleagues (2006), Vartak and colleagues (2008) found evidence that major teaching hospitals performed better in one quality indicator (PSI 11- postoperative respiratory failure) while performing worse in others (PSI 12 - postoperative pulmonary embolism or deep vein thrombosis and PSI 13- postoperative sepsis). Rivard and colleagues (2010) also uncovered mixed results in the relationship between patient safety indicators and teaching status in both VA hospitals and nonfederal hospitals. Major teaching hospitals had a higher likelihood of adverse events in both VA hospitals and nonfederal hospitals in iatrogenic pneumothorax and infection due to medical care. However, minor teaching VA hospitals and major teaching nonfederal hospitals had lower

likelihood of mortality in low mortality DRGs. Although evidence is mixed, Rivard and colleagues found that teaching status was the structural characteristic most associated with PSIs. Thus, for this study, it is anticipated that those military hospitals with a greater number of residency programs would exhibit better quality compared with those with fewer residents and the following hypothesis is tested:

> Hypothesis 1: The average level of quality across the six years will be higher for major teaching hospitals than minor and non-teaching hospitals.

For military hospitals, major teaching hospitals are all medical centers with residency training programs. Graduate medical education programs have been shown to decrease staff physician productivity (Linna, 1998; Johnson, Shah, Rechner, & King, 2008). Major teaching hospitals with many graduate medical education programs may have lower staff physician productivity, but that loss may be countered by the workload generated by the higher volume of residents at the facilities. Major teaching hospitals receive most of the inpatient wounded personnel from the war due to their enhanced capabilities. The vast majority of casualties returning from the war would be treated by major teaching hospitals. The complexities of running graduate education programs and providing tertiary, advanced therapies combined with receiving severely wounded patients requiring extensive care would make the larger, major teaching hospitals less able to adapt to the environmental jolts of war than the smaller minor and nonteaching hospitals. In terms of the rate of change for adaptation and adjustment to the jolt, the following two hypotheses are tested:

> Hypothesis 2: Major teaching hospitals' rate of change in quality will be slower than minor and non-teaching hospitals' rate of change in quality.

> Hypothesis 3: Major teaching hospitals' rate of change in productivity will be slower than minor and non-teaching hospitals' rate of change in productivity.

Although most of the severely wounded soldiers are transported to major teaching hospitals, wounded soldiers also are sent to minor teaching hospitals. Nursing workload is affected by patient acuity, patient turnover, and patient characteristics; nursing workload in turn moderates the relationship between nurse staffing and patient outcomes (Duffield et al., 2011; Park et al., 2012). The number of wounded soldiers who tend to have higher acuity and more complex injuries would influence hospital performance in quality. As the percentage of wounded soldiers increase, quality will decrease. Therefore, for this study, it is anticipated that as hospitals' wounded inpatient admissions increase as a percentage of total admissions, hospitals would demonstrate worse quality and the following hypothesis is tested:

> Hypothesis 4: There will be an inverse relationship between the percentage of wounded soldiers and quality.

When OEF and OIF began in 2001 and 2003, respectively, Army troop rotations lasted 12 months and Marine troop rotations lasted seven months. Air Force troop deployments lasted less than six months while the Navy troops on ships deploy for six months at a time. The differences across the three branches of service (Army, Navy, Air Force) in how long personnel are deployed and away from their usual workplace may have an influence on productivity and quality due to skill degeneration and reintegration issues such as physical and mental concerns. The Army also has the highest number of troops deployed and medical assets necessary to support the troop deployments among the three services. The Army also has the greatest number of major and minor teaching hospitals in comparison to the other services, thereby having more hospitals that see relatively more complex patients and that provide more complex services. Therefore, the ability of the Army hospitals to adapt their structure to the jolt related uncertainty by changing staffing levels (see conceptual model in Figure 1) to improve performance is slower

than the Navy and Air Force hospitals. Thus, in terms of the rate of change for adaptation and adjustment to the jolt by service affiliation, the following two hypotheses are tested:

> Hypothesis 5: Army hospitals' rate of change in productivity will be less rapid than Air Force and Navy hospitals' rate of change in productivity.

> Hypothesis 6: Army hospitals' rate of change in quality will be less rapid than Air Force and Navy hospitals' rate of change in quality.

As OEF and OIF have progressed, the military and the medical community has transformed into a more modular, mobile force. Global sourcing for operational deployments has spread the impact of losing staff to deployments through many hospitals. The impact of the war on each hospital's productivity and quality is likely to differ based on the number of FTEs deployed as a result of providing medical support for combat operations (jolt related uncertainty). Deployment of staff creates a situation of staff turnover, which negatively influences productivity while new staff is recruited and trained (Hayes, et al., 2006). Studies have shown that nursing turnover creates hospital inefficiencies; increased hospital operating costs; and decreased nursing home quality (Alexander et al., 1994; O'Brien-Pallas et al., 2006; Castle & Engberg, 2005). O'Brien-Pallas and colleagues (2006) found that the highest direct cost due to turnover was incurred by hiring temporary replacements while the highest indirect cost was the result of decreases in productivity. Thus, it is expected that as hospitals' percentage of deployed staff increases, hospitals would suffer from increasing turnover and demonstrate decreasing productivity and the following hypothesis is tested:

> Hypothesis 7: There will be an inverse relationship between percentage of deployed FTEs and productivity.

The deployed staff must be replaced either by contractors or reservist personnel who need unit specific training before assuming duties in the military hospitals.

Summary

In this chapter, the theoretical framework of contingency theory as it relates to military hospital response to an environmental jolt was used to develop study hypotheses in support of the research question. The characteristics of the hospital such as teaching status and branch of armed service will influence how fast the organization would be able to adapt and influence measures of performance such as quality and productivity. The jolt related uncertainty of deployed FTEs and wounded patients will influence hospital quality and productivity.

Chapter 4 specifies the research methods to include research design, data sources, specific variables and methodology for the analysis. Retrospective panel data utilizing multilevel analysis is the basis for the analytic approach. How different characteristics of the military hospital influence the pattern of performance in quality and productivity over the course of adapting to the war is analyzed.

Chapter 4: Methods

The purpose of this research is to determine what impact the wars in Iraq and Afghanistan have had on the productivity and quality of United States military hospitals over the fiscal years 2001-2006. How productivity and quality changed over the years and what effect the wars have had on the productivity and quality of military hospitals was explored. The uncertainty created by the jolt of war and the organizational adaptation arising from changing its structure in the attempt to move from misfit to fit with the environment will influence organizational performance in productivity and quality. This chapter lays out the methods used to test military hospital performance using a Contingency Theory framework.

Design

This study is a retrospective panel analysis where military hospitals (unit of analysis) are observed over a six-year period (fiscal years 2001 to 2006). Two strengths of panel analysis are the ability to study dynamic relationships and to model heterogeneity among observed units (Frees, 2004). In longitudinal analysis, data are collected over multiple time periods from the same organizations; therefore, there is bound to be some degree of correlation in the dependent variable. One of the drawbacks of longitudinal studies is attrition. For the current study, ten hospitals either converted to outpatient clinics and stopped providing inpatient services or closed entirely. The number of military hospitals changed from 77 in fiscal year 2001 to 67 hospitals at the end of fiscal year 2006 (Table 1), creating an unbalanced data set for this study. Multilevel analysis is one of several methodologies that use all available information in unbalanced data

sets to determine the effects due to time between groups instead of decreasing sample size to hospitals with data in all time periods. A fixed effects model may also be applied to unbalanced panels after application of within or first difference transformations; however, time constant explanatory variables of interest (structural variables such as branch of service and teaching status) would not be estimated. Since the change in quality and productivity over the six-year period while accounting for hospital structural characteristics is the focus of this study, multilevel mixed effects models are utilized. Fixed effects models are also applied for sensitivity analyses of the results.

Data

The MHS Data Repository (MDR) is the primary database for the current research. MDR contains population, clinical, and financial data for all care provided in the MHS (TRICARE Management Activity, 2010). MDR has enrollment and eligibility information, inpatient and outpatient claims for purchased care, inpatient, outpatient, and laboratory information for direct care, medication information (obtained from mail order, retail pharmacy, and military pharmacy) and workload and cost accounting information (TRICARE Management Activity, 2010). Data from numerous information systems in the MHS are funneled to the centralized MDR, enabling corporate decision making at all levels: hospital, region, branch of service and MHS.

Annual data for each military hospital are used for analysis. Since budget cycles and major policy changes occur in fiscal years, a one-year period begins on October 1st and ends on September 30th of the following calendar year. This study covers six fiscal years, FY 2001 to FY 2006, from October 1, 2000 through September 30, 2006. This timeframe was chosen to provide data before the wars in Iraq and Afghanistan began for comparison and enough years afterwards

to demonstrate evidence of adaptations. This timeframe covers one year before the war began in Afghanistan (October 2001) and three years after the war began in Iraq (March 2003). This study period ends before the surge in mid 2007 that stabilized Iraq. Data from MDR address one of the limitations from some studies where indirect and direct nursing care hours are combined since staffing hours for inpatient, outpatient and administrative cost centers are separated. The validity and reliability of military electronic patient data are comparable to other large civilian information systems (Hoge, Auchterlonie, & Milliken, 2006).

The Virginia Commonwealth University Institutional Review Board determined that this research met the criteria for exempt status. An approved Data Use Agreement is on file with the TRICARE Management Activity Privacy Office for this study.

Sample.

The sample is based on all military hospitals of the three branches of the armed forces from FY 2001 to 2006. Of the total 77 military hospitals at the beginning of the study (Table 1), seven hospitals stopped offering inpatient services between 2001 and 2003. Since most of the impact of war should be after the invasion of Iraq in 2003, hospitals without at least three full years of data were eliminated from the sample. The final sample consisted of 70 hospitals in 2001 going down to 62 in 2006. One Air Force hospital was devastated by Hurricane Katrina near the end of FY 2005 so it provided no data for FY 2006, resulting in 61 hospitals in 2006 (See Table 2). Each hospital in each year becomes an observation, resulting in 407 total observations for the multilevel model.

Dependent variables.

The variables for the study were designed based on the theoretical framework of contingency theory. The dependent variables, productivity and quality, represent the

Table 2.
Types of Military Hospitals by Service over Time for Sample (Productivity)

		2001	2002	2003	2004	2005	2006
Major Teaching	Army	5	5	5	5	5	5
	Air Force	2	2	2	2	2	2
	Navy	3	3	3	3	3	3
Minor Teaching	Army	6	6	6	6	6	6
	Air Force	4	4	4	4	4	3
	Navy	5	5	5	5	5	5
Non-Teaching	Army	12	12	12	12	12	11
	Air Force	8	8	8	8	6	5
	Navy	6	6	6	6	6	5
Overseas	Army	4	4	4	4	4	3
	Air Force	6	6	6	6	6	5
	Navy	9	9	9	8	8	8
	Total DoD	70	70	70	69	67	61

performance construct. The following sections describe the construction of the measures used to represent productivity and quality in the analysis. Table 3 delineates measures for the constructs and variables in the conceptual model (Figure 1). The "Level" column in Table 3 applies to multilevel models, and it is explained in more detail in the Statistical Modeling section.

Productivity.

Productivity was measured by the number of RWPs (weighted discharges) per 1000 patient bed days. Since bigger hospitals with more occupied beds will have higher numbers of RWPs, the standardized ratio of RWPs generated per 1000 patient bed days is a more appropriate comparison among hospitals. The number of admissions or discharges is a common productivity measure for hospitals (Harrison & Coppola, 2007; Fulton et al., 2007; Mandiakis et. al., 1999).

Table 3

Constructs and Variables for Productivity and Quality Models

Level[a]	Construct	Variable	Definition / Measure
Dependent Variables			
	Performance: Productivity	Productivity (PROD)	Inpatient workload: Number of RWP weighted discharges per year per 1000 patient bed days
	Performance: Quality	Quality Indicators (PSI1) (PSI3) (PSI12) (PSI14) (PSI15) (IQI20) (IQI23) (IQI33)	Quality Indicators: Observed number of adverse events per year
Independent Variables			
Productivity/Quality Model			
Level 1	Uncertainty (UNCER)	Wounded discharges (WOUND)	Percent wounded discharges: War related discharges (DX codes E990.0-E999.1) / Total discharges x 100%
Level 1	Structure (STRUC)	RN staffing (RN)	RN FTEs in inpatient areas: Annual RN FTEs per 1000 patient bed days
Level 1	Structure (STRUC)	Clinician Staffing (CLIN)	Clinician FTEs in inpatient areas: Annual physician FTEs and advanced practice nurse FTEs per 1000 patient bed days
Level 1	Organizational Response (RESP)	Contractor FTE (CONTRACT)	Contract FTEs in inpatient areas: Number of contract FTEs per 1000 patient bed days
Level 1	Uncertainty (UNCER)	Deployed staff (DEPLOY)	Percent deployed FTE: Deployed FTE / RN and Clinician FTE x 100%
Level 1		Time (TIME)	Fiscal Year: 2001=0; 2002=1; 2003=2; 2004=3; 2005=4; 2006=5
Level 2	Structure (STRUC)	Teaching Status (MINOR) (NON) Type of Hospital[b] (MINOR) (NON) (OS)	Major Teaching (4 or more residency programs), Minor Teaching (1-3 residency programs), Non-Teaching (0 residency programs): Major Teaching =referent; MINOR = 1 if Minor Teaching, 0 otherwise; NON = 1 if Non-Teaching, 0 otherwise; OS=1 if Overseas, 0 otherwise
Level 2	Structure (STRUC)	Branch of Service (NAVY) (AF)	Branch of Armed Service (Army, Navy, Air Force): Army = referent; NAVY = 1 if Navy, 0 otherwise; AF = 1 if Air Force, 0 otherwise
Quality Model Additional Variables[c]			
Level 1	Control Variable	Case Mix Index (CMI)	Case Mix Index: Annual RWP weighted discharges / Annual discharges
Level 1	Control Variable	Offset Factor (OFFSET)	Poisson offset factor: Ln (expected number of adverse events at each hospital per year)

Note. [a] Level 1 variables are time and time varying variables; Level 2 variables are time-invariant variables

[b] Type of Hospital includes teaching status categories plus overseas hospitals

[c] Additional time varying control variables only needed for quality model

Some advantages of using RWPs are: it is readily available in military medical databases already accounting for resource intensity, and it has been used in many previous research studies on military hospitals. A disadvantage is that the measure is unique to the military; therefore, it is not easy to use this measure to make comparisons outside the military setting.

Quality (quality indicators).

AHRQ's set of quality indicators (QI) include inpatient quality indicators (IQI), patient safety indicators (PSI), pediatric quality indicators (PDI) and prevention quality indicators (PQI). IQIs are measures of inpatient mortality for medical conditions and surgical procedures, utilization of procedures, and volume of procedures. These measures reflect quality in hospitals. PSIs are measures that identify potential in-hospital complications and adverse events following surgeries, procedures, and childbirth. PDIs combine the function of IQIs and PSIs into one set of measures for children. PQIs help to identify hospital stays that are ambulatory care sensitive conditions (AHRQ, 2006-a). The AHRQ PSIs are easily implemented, low-cost, and relatively free of collection bias (Rivard, Rosen, & Carroll, 2006). Due to these advantages, PSIs may be a good tool for senior managers to use in overall system trending and benchmarking in healthcare. AHRQ QIs are used widely in the healthcare industry for quality improvement, and they were determined to have face and content validity (Hussey et al., 2006).

Claims data from MDR was used with AHRQ Quality Indicator Software to calculate each hospital's expected and observed adverse events for each IQI and PSI to assess quality for inpatient service. Observed adverse events for each PSI and IQI became the dependent variables for the quality mixed effects models. To decrease bias, all admissions that were transferred out to another acute care hospital or transferred in from another acute care hospital were eliminated prior to calculating expected and observed adverse events using the AHRQ QI software. Patients

that were transferred to another hospital and eventually died would skew the mortality rates for care that was rendered at the original and receiving hospitals.

Although IQIs (mortality rates) are good outcome measures for many hospitals, deaths are rare occurrences for many military hospitals. The military hospitals tend to serve a younger, healthier population than general civilian acute care hospitals. Therefore, there are many hospitals with zero expected adverse events for the IQIs, and many of the mortality indicators could not be used in this study. The list of PSIs and IQIs utilized in the study are listed in Table 4. PSIs and IQIs were excluded if not enough hospitals had patients at risk for the indicator being measured. Specifically, for each IQI and PSI, hospitals in each fiscal year with an observed denominator of patients at risk less than 15 were excluded. Then, if fewer than half of the observations (hospitals per year) were left for each quality indicator, the indicator was excluded from analysis. Most of the mortality quality indicators (IQI 8-19) were excluded from the analysis due to too few hospitals having adequate patients at risk. The total number of observations for the remaining IQIs and PSIs varied between 230 and 407. In addition, if very few hospitals had non-zero occurrence or very low expected occurrence, these hospitals were excluded. For example, PSI 13 (Postoperative Sepsis) was eliminated because the range of observed counts was zero to two and only 12 of 171 occurrences for all six years were non-zero. All hospitals had an expected count of less than one for PSI 13. PSI 13 has been identified as occurring too infrequently in hospitals to be a good measure of patient safety in a previous study (Hussey et al., 2009).

Table 4

AHRQ Quality Indicators Used in the Study

Category	Quality Indicator	Indicator Name
Patient Safety	PSI 1	Complications of Anesthesia
	PSI 3	Decubitus Ulcer
	PSI 12	Postoperative Pulmonary Embolism or Deep Vein Thrombosis
	PSI 14	Postoperative Wound Dehiscence
	PSI 15	Accidental Puncture or Laceration
Inpatient Quality	IQI 20	Pneumonia Mortality Rate
	IQI 23	Laparoscopic cholecystectomy Rate
	IQI 33	Primary Cesarean delivery Rate

Independent variables.

Wounded discharges.

Discharges are coded with specific E diagnosis codes to specify external causes of injury. The war related E codes are between E990.0 and E999.1 (TRICARE Management Activity, 2011-c). Discharges with these E codes were designated as wounded discharges to calculate the percent of wounded discharges per hospital per year.

Staff FTEs.

The Medical Expense & Performance Reporting System (MEPRS) is a system for collecting uniform medical personnel, expense, and workload data for all three services. MEPRS provides the FTE reporting data stored in the MDR. All inpatient work centers have MEPRS codes beginning with the letter "A." The system distinguishes by type of personnel; therefore, RN FTEs assigned to inpatient areas will have work hours captured under the "A" work center.

The variable RN Staffing only includes inpatient RN FTEs. For this analysis, RN Staffing is calculated as FTEs per 1000 patient bed days for each hospital.

In contrast, it is more difficult to determine clinician assignment to inpatient areas. Clinicians for this study are defined as physicians and physician extenders such as physician assistants and advanced practice nurses (i.e., clinical nurse specialists, certified nurse anesthetists, midwives and nurse practitioners). For the variable Clinician Staffing, differentiating between outpatient and inpatient staff is more difficult because the clinicians are only assigned to outpatient clinics. Inpatient work hours should be attributed to the inpatient work centers for the amount of time clinicians work in inpatient areas, but the actual number of clinician FTEs for each hospital may be understated. To appropriately account for clinicians who would work in inpatient areas, outpatient clinics were matched by broad categories (i.e., medicine, surgery, and obstetrics and gynecology) to inpatient counterparts to exclude clinicians working in areas who would not have work hours attributed to inpatient work centers. Clinician Staffing includes both inpatient and outpatient clinician FTEs. Clinician Staffing is also calculated as FTEs per 1000 patient bed days for each hospital.

The variable Contractor FTE includes all clinician and nursing staff contractors assigned to inpatient areas. Similar to Clinician Staffing, contractor clinicians also include physician extenders. Unlike permanent clinicians, however, contractor clinician hours are attributed correctly to the work center where they work, so time spent working in inpatient work centers are clearly distinguishable from time spent in outpatient work centers. For this study, RN Staffing and Contractor FTE only include inpatient staff FTEs whereas Clinician Staffing includes both inpatient and outpatient FTEs.

Deployed FTE.

MEPRS codes beginning with the letter "G" designate readiness related activities in support of the military mission rather than patient care. Specifically, "GA" codes designate administrative requirements involved in implementing readiness activities at the medical facilities such as administering immunizations for deploying military members. The "GD" account captures the deployed status of personnel from the military facilities (Office of the Assistant Secretary of Defense Health Affairs, 2008). The number of FTEs in these two "G" accounts is the number of Deployed FTEs for the effect of war on each hospital. Only deployed clinicians, RNs and paraprofessionals are included for the Deployed FTE variable. Personnel such as dentists and administrators were excluded from Deployed FTE since they would not influence productivity and quality of inpatient services. The denominator is the total clinician, RN, and paraprofessional FTEs for the hospital in the inpatient and outpatient service areas. Excluded are ancillary, dental, veterinary and administrative areas. The outpatient areas were included because it is impossible from the data system to determine where the deployed FTEs were assigned prior to readiness related activities.

Teaching status.

As discussed earlier in the literature review, teaching status was categorized as major teaching for hospitals with four or more GME programs, minor teaching for hospitals with one to three GME programs, and non-teaching for hospitals with no GME. The major teaching hospitals were selected as the referent category. There are 19 hospitals that are located overseas in FY 2001. Initially, location was considered as a control variable separately, but since all the overseas hospitals are non-teaching and Landstuhl Regional Medical Center has the capabilities and services more like teaching hospitals except GME, classifying overseas hospitals as a subset

of the non-teaching hospitals within the teaching status variable seemed to be the most parsimonious. Therefore, the variable Teaching Status is represented by three dummy variables MINOR, NON and OS, representing minor teaching hospitals, non-teaching hospitals, and overseas hospitals, respectively. Major teaching hospital is the reference category. For clarity, when OS is included, the term "types of hospitals" is used. The term "teaching status" refers only to major teaching, minor teaching and non-teaching categories.

Branch of service.

The variable Branch of Service is the military hospital's branch of the Armed Service: Army (referent), Navy (NAVY) or Air Force (AF). The variable Branch of Service is represented by two dummy variables, NAVY and AF. Since most military hospitals are affiliated with the Army, Army was chosen as the reference category.

Case mix index.

The annual case mix index (CMI) for military hospitals is computed by taking the total RWP weighted discharges produced divided by the total number of discharges for the year. The CMI represents the case complexity of the average inpatient for each hospital. The CMI for each hospital is included as a control variable, and it is only used in the quality models to control for complexity.

Statistical Modeling

Observations over a six-year period are nested within hospitals; therefore, to determine the effects of the independent variables on productivity and quality, two different multilevel mixed effects models were used. The type of statistical model is determined by whether the dependent variable is productivity or quality. A random coefficient modeling (RCM) framework is used to test the continuous variable, Productivity. To test the quality variables, multilevel

mixed effects Poisson regression is used because the quality variables are counts of deaths or adverse events. All models were analyzed using Stata version 11.

Multilevel modeling.

This section discusses the multilevel model in general. Since multilevel modeling is predominately used with continuous dependent variables, the methodology is discussed using the variable Productivity. To determine change in productivity over the period 2001-2006, a multilevel mixed effects model using a random coefficient modeling (RCM) framework was used with the continuous dependent variable. According to Bliese and Ployhart (2002), “RCM models estimate growth parameters on the available data and do not require complete data from all respondents” (p. 383). Assuming the attrition of study hospitals is exogenous, the multilevel model is an appropriate technique to utilize for this study. Observations over multiple time periods (Level 1) are nested within hospitals (Level 2). The two-level mixed effects model examines three things: 1) change patterns of the dependent variable over time for the sample as a whole; 2) organizational differences in overall levels of the dependent variable; and 3) organizational differences in change patterns of the dependent variable over time (Bliese & Ployhart, 2002). The general multilevel mixed effects model using Raudenbush and Byrk (2002) notation is:

(Level 1) $$Y_{ij} = \pi_{0j} + \pi_{1j}(TIME_{ij}) + r_{ij}$$

(Level 2) $$\pi_{0j} = \beta_{00} + u_{0j}$$
$$\pi_{1j} = \beta_{10} + u_{1j}$$

where
π_{0j} = organization j’s initial intercept
π_{1j} = organization j’s initial slope
r_{ij} = residual error
β_{00} = the average initial intercept across organizations
β_{10} = the average initial slope across organizations

u_{0j} = residual intercept, the difference between organization j's intercept and the average intercept across organizations
u_{1j} = residual slope, the difference between organization j's slope and the average slope across organizations
$TIME_{ij}$ = time period i for organization j

Once combined, the multilevel equation is:

$$Y_{ij} = [\beta_{00} + \beta_{10} (TIME_{ij})] + [u_{0j} + u_{1j} (TIME_{ij}) + r_{ij}]$$

The first bracketed term is the fixed effects part of the model, and the second bracketed term is the random effects part of the model.

Level 1 model structure.

It is important to determine the relationship of the dependent variable with regard to time in Level 1 of the model before adding any other variables. In order to correctly model the pattern of observations over time, the relationship between each dependent variable and time were analyzed without any other predictors. Empirical growth plots for each hospital are created using a scatterplot of time versus the dependent variable. The change trajectory is the fitted trend line of each scatterplot . Figure 2 depicts the productivity change trajectories on an empirical growth plot for the first 12 hospitals, giving a quick sense of the different patterns and rates of change in productivity. Hospital #8 has a rate of increase while Hospital #10 has a rate of decrease in productivity. In a similar vein, different patterns and rates of change are evident for hospitals in the quality indicators, IQIs (Figure 3: change trajectories for IQI 20-Pneumonia Mortality) and PSIs (Figure 4: change trajectories for PSI 15-Accidental Puncture or Laceration). For all three types of dependent variables, it is important to specify parameters that will account for the different change patterns over time for each organization; therefore, the slopes and intercepts are allowed to randomly vary for each military hospital with mixed effects models.

Figure 2. Empirical Growth Plots of 12 Military Hospitals' Productivity from 2001 to 2006.

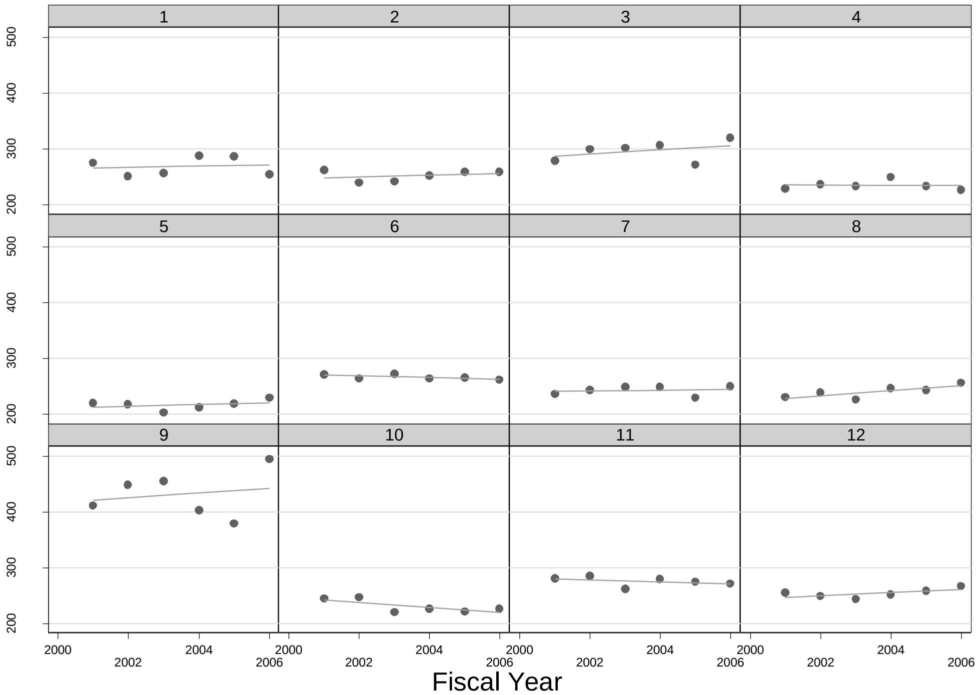


Figure 3. Empirical Growth Plots of 12 Military Hospitals for Inpatient Quality Indicator 20-Pneumonia Mortality from 2001 to 2006.

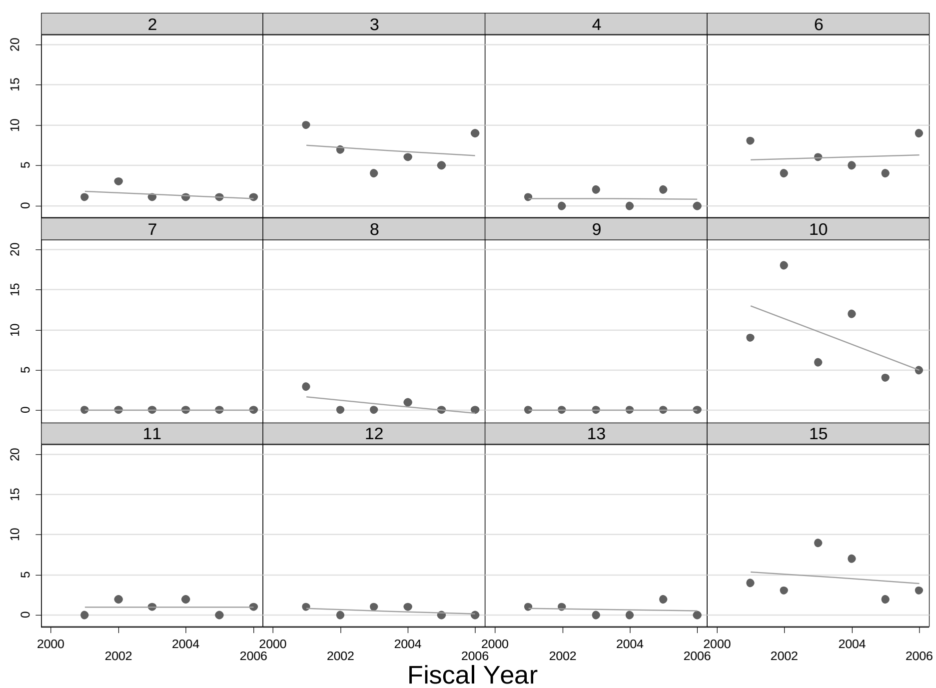


Figure 4. Empirical Growth Plots of 12 Military Hospitals for Patient Safety Indicator 15-Accidental Puncture or Laceration from 2001 to 2006.

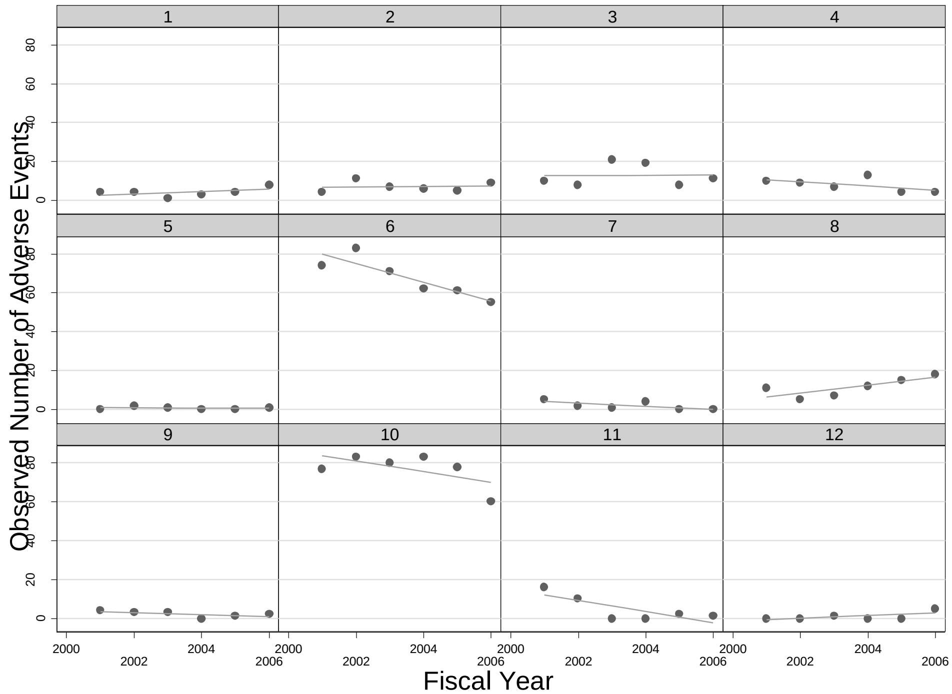


Table 5 contains the results of the comparisons of linear time models and quadratic time models for each dependent variable. The significance of the relationship between time and the dependent variable was determined by examining the parameter estimates and the corresponding z values. TIME was significantly related to all inpatient quality indicators and productivity, but TIME was only significantly related to Postoperative Wound Dehiscence (PSI 14) and Accidental Puncture and Laceration (PSI 15) for the patient safety indicators. To compare the linear model with the quadratic model, the deviance of the simpler model versus the more complex model was determined using a log likelihood test (Bliese & Ployhart, 2002). Only two of the quality variables (PSI 12-Postoperative Pulmonary Embolism or Deep Vein Thrombosis and PSI 14-Postoperative Wound Dehiscence) and productivity had significant $TIME^2$ components when analyzing the deviance via change in χ^2 from the linear model to the quadratic

Table 5
Comparison of Linear and Quadratic Time Models for Dependent Variables

		Linear Time Model		Quadratic Time Model		Change in χ^2	
		z	p	z	p	χ^2	p
IQI 20	TIME	-5.30	< 0.01	-2.44	0.02		
	$TIME^2$			0.93	0.35		
	Log Likelihood	8.17	< 0.01	8.14	< 0.01	0.85	0.36
IQI 23	TIME	2.74	< 0.01	0.24	0.81		
	$TIME^2$			0.57	0.57		
	Log Likelihood	62.04	< 0.01	61.94	< 0.01	0.33	0.57
IQI 33	TIME	8.85	< 0.01	2.23	0.03		
	$TIME^2$			0.26	0.79		
	Log Likelihood	727.26	< 0.01	727.28	< 0.01	0.07	0.79
PSI 1	TIME	0.81	0.42	-0.89	0.37		
	$TIME^2$			1.17	0.24		
	Log Likelihood	63.69	< 0.01	63.55	< 0.01	1.35	0.25
PSI 3	TIME	1.27	0.20	0.73	0.46		
	$TIME^2$			-0.39	0.70		
	Log Likelihood	245.74	< 0.01	245.68	< 0.01	0.15	0.70
PSI 12	TIME	1.26	0.21	2.84	< 0.01		
	$TIME^2$			-2.59	< 0.01		
	Log Likelihood	427.20	< 0.01	428.23	< 0.01	6.79	<0.01*
PSI 14	TIME	-1.99	0.05	2.33	0.02		
	$TIME^2$			-3.00	< 0.01		
	Log Likelihood	0.13	0.36	0.19	0.33	9.7	<0.01*
PSI 15	TIME	2.07	0.04	-0.97	0.33		
	$TIME^2$			1.62	0.11		
	Log Likelihood	501.05	< 0.01	500.17	< 0.01	2.62	0.11
PROD	TIME	-5.87	< 0.01	-1.22	0.22		
	$TIME^2$			-0.49	0.62		
	Log Likelihood	443.97	< 0.01	448.40	< 0.01	4.66	0.03*

Note: *Change in χ^2 is significant

model. To minimize the number of coefficients estimated in the models, the linear time model ($Y_{ij} = \pi_{0j} + \pi_{1j}(TIME_{ij}) + r_{ij}$) instead of the quadratic time model ($Y_{ij} = \pi_{0j} + \pi_{1j}(TIME_{ij}) + \pi_{2j}(TIME^2_{ij}) + r_{ij}$) was used for the Level 1 structure in all analyses. Then, time-varying predictors (listed in Table 3 as Level 1) are added to determine the final Level 1 model, and time invariant predictors (listed in Table 3 as Level 2) are added to Level 2 for the final model.

Productivity multilevel model.

Along with TIME, the Level 1 time varying variables from Table 3 (Wounded Discharges, RN Staffing, Clinician Staffing, Deployed FTE and Contract FTE) are included in the equation for Level 1. The hypothesized equation for the final Level 1 model for productivity is:

(Level 1)
$$PROD_{ij} = \pi_{0j} + \pi_{1j}(TIME_{ij}) + \pi_{2j}(WOUND_{ij}) + \pi_{3j}(RN_{ij}) + \pi_{4j}(CLIN_{ij}) + \pi_{5j}(DEPLOY_{ij}) + \pi_{6j}(CONTRACT_{ij}) + r_{ij}$$

After the Level 1 model structure is determined, time invariant explanatory variables (X_j) identified as predictors in the Level 2 model in Table 3 are added to the Level 2 part of the model to determine if organizations have different intercepts (π_{0j}) and slopes for TIME (π_{1j}).

(Level 2)
$$\pi_{0j} = \beta_{00} + \beta_{01}(X_j) + u_{0j}$$
$$\pi_{1j} = \beta_{10} + \beta_{11}(X_j) + u_{1j}$$
$$\pi_{2j} = \beta_{20}$$
$$\pi_{3j} = \beta_{30}$$
$$\pi_{4j} = \beta_{40}$$
$$\pi_{5j} = \beta_{50}$$
$$\pi_{6j} = \beta_{60}$$

Adding branch of service variables (AF and NAVY) and teaching status (MINOR, NON, OS) for X_j in Level 2 and substituting into the Level 1 linear time model for productivity [$PROD_{ij} = \pi_{0j} + \pi_{1j}(TIME_{ij}) + r_{ij}$] derives the following equation:

$$PROD_{ij} = \beta_{00} + \beta_{10}\,(TIME_{ij}) + \beta_{01}\,(AF_j) + \beta_{02}\,(NAVY_j) + \beta_{03}\,(MINOR_j) + \beta_{04}\,(NON_j) + \beta_{05}\,(OS_j) + \beta_{11}\,(AF_j)\,(TIME_{ij}) + \beta_{12}\,(NAVY_j)\,(TIME_{ij}) + \beta_{13}\,(MINOR_j)\,(TIME_{ij}) + \beta_{14}\,(NON_j)\,(TIME_{ij}) + \beta_{15}\,(OS_j)\,(TIME_{ij}) + \beta_{20}\,(WOUND_{ij}) + \beta_{30}\,(RN_{ij}) + \beta_{40}\,(CLIN_{ij}) + \beta_{50}\,(DEPLOY_{ij}) + \beta_{60}\,(CONTRACT_{ij}) + [u_{0j} + u_{1j}\,(TIME_{ij}) + r_{ij}]$$

The Level 2 predictors create cross product parameters with time in growth models (multilevel mixed effects models with time) once hospital level time invariant predictors were included in the slope for TIME (π_{1j}).

Quality multilevel models.

To determine change in quality over the period 2001-2006, a Poisson regression mixed effects model is used. Poisson regression is appropriate when examining count data, such as mortality and adverse events in hospitals where the distribution is generally not normally distributed. Applying ordinary least squares (OLS) regression with count data is not appropriate because the predicted values may fall below zero (Cohen, Cohen, West, & Akien, 2003). Although there are numerous zero observations, the zero-inflated Poisson regression model is not appropriate because hospitals that do not have patients at risk for the quality indicator (structural zeros) are already excluded from the analysis for that quality indicator.

Individual discharge information for all military hospitals are analyzed using AHRQ QI software to determine observed adverse events and expected adverse events for each quality indicator. The natural log of the expected number of adverse events for each hospital (OFFSET) is included in the Poisson regression equation as an offset factor, and the regression coefficient is constrained to equal 1. The offset factor is necessary to account for the differences in exposure of each hospital to provide context for the observed adverse events.

The general Poisson regression equation for the expected number of events is:

$$E(Y_{ij} \mid X_{ij}) = exp\,(X_{ij}\,\Pi)$$

where X is a set of explanatory variables and Π is a set of parameters. The model for the mixed effects Poisson regression is:

$$\log(\lambda_{ij}) = \pi_{0j} + \pi_{1j} TIME_{ij} + r_{ij}$$
$$\pi_{0j} = \beta_{00} + \beta_{01} X_j + \zeta_{0j}$$
$$\pi_{1j} = \beta_{10} + \beta_{11} X_j + \zeta_{1j}$$

where :
π_{0j} = overall average intercept
π_{1j} = overall average slope
X_j = vector of explanatory variables
B_{01} and β_{11} = parameter vectors
ζ_{0j} = hospital specific random intercept
ζ_{1j} = hospital specific random coefficient

The models for quality also include the time varying control variable, case mix index (CMI), in Level 1 to account for hospitals that have more severe patients. Hence, the final quality equation is:

$$E(QUAL_{ij}|X_{ij}) = exp\{OFFSET + \beta_{00} + \beta_{10} (TIME_{ij}) + \beta_{01} (AF_j) + \beta_{02} (NAVY_j) + \beta_{03} (MINOR_j) + \beta_{04} (NON_j) + \beta_{05} (OS_j) + \beta_{11} (AF_j) (TIME_{ij}) + \beta_{12} (NAVY_j) (TIME_{ij}) + \beta_{13} (MINOR_j) (TIME_{ij}) + \beta_{14} (NON_j) (TIME_{ij}) + \beta_{15} (OS_j) (TIME_{ij}) + \beta_{20} (WOUND_{ij}) + \beta_{30} (RN_{ij}) + \beta_{40} (CLIN_{ij}) + \beta_{50} (DEPLOY_{ij}) + \beta_{50} (DEPLOY_{ij}) + \beta_{60} (CONTRACT_{ij}) + \beta_{70} (CMI_{ij}) + [\zeta_{0j} + \zeta_{1j} (TIME_{ij}) + r_{ij}]\}$$

The hypotheses from Chapter 3 align with the parameters in the Productivity and Quality Multilevel Models presented according to Table 6.

Summary

In summary, this study is a retrospective panel analysis of military hospital performance over a six-year period (FY 2001 to FY 2006) to determine how productivity and quality changed over the years as a result of wars in Iraq and Afghanistan. To determine change in productivity, a multilevel mixed effects model using a random coefficient modeling framework is used. For changes in quality, a set of multilevel mixed effects Poisson regression models are used.

Table 6

Hypotheses and Parameter Linkage by Dependent Variable

Dependent Variable	Independent Variable (*Parameter*)	Hypothesis
Productivity		
	Teaching Status (β_{13}, β_{14})	Hypothesis 3: Major teaching hospitals' rate of change in productivity will be slower than minor and non-teaching hospitals' rate of change in productivity.
	Branch of Service (β_{11}, β_{12})	Hypothesis 5: Army hospitals' rate of change in productivity will be less rapid than Air Force and Navy hospitals' rate of change in productivity.
	Deployed FTE (β_{50})	Hypothesis 7: There will be an inverse relationship between percentage of deployed FTEs and productivity.
Quality		
	Teaching Status (β_{03}, β_{04})	Hypothesis 1: The average level of quality across the six years will be higher for major teaching hospitals than minor and non-teaching hospitals.
	Teaching Status (β_{13}, β_{14})	Hypothesis 2: Major teaching hospitals' rate of change in quality will be slower than minor and non-teaching hospitals' rate of change in quality.
	Wounded Discharge (β_{20})	Hypothesis 4: There will be an inverse relationship between the percentage of wounded soldiers and quality.
	Branch of Service (β_{11}, β_{12})	Hypothesis 6: Army hospitals' rate of change in quality will be less rapid than Air Force and Navy hospitals' rate of change in quality.

Chapter 5 presents descriptive analysis of the variables in the study and the results of the multilevel analyses of the productivity and quality models presented in this chapter.

Chapter 5: Results

The purpose of this research was to determine what impact the wars in Iraq and Afghanistan have had on the productivity and quality of United States military hospitals over the fiscal years 2001-2006. How productivity and quality changed over the years and what effect the wars have had on the productivity and quality of military hospitals were explored. In particular, the research aimed to answer whether productivity and quality trends differ by type of hospital.

Descriptive Analysis

A total of 407 observations over six years were included in the study as described earlier and is reflected in Table 2. Descriptive statistics for the sample are listed in Table 7. Statistics are divided by time varying Level 1 independent variables, time invariant Level 2 independent variables and dependent variables. For the time varying variables, the percentage of wounded discharges to total discharges (WOUND) range from some hospitals having zero to at least one hospital having as much as 14.72% of the discharges from wounded service members. Nurse staffing (RN) ranges from 0.34 RN FTEs per 1000 patient bed days to 18.06 RN FTEs per 1000 patient bed days; however, an average of 6.42 RN FTEs per 1000 patient bed days signals that there are some hospitals that are outliers and have much more staffing than the average hospital. Clinician staffing (CLIN) follows a similar pattern as nurse staffing with a range of 2.74 to 36.3 FTEs per 1000 patient bed days with an average of 9.16 FTEs. The average percentage of deployed staff (DEPLOY) was 8.13%. Finally, the average case mix index (CMI) is 0.74, signaling that on average, military hospitals do not treat very complex patients.

Table 7
Descriptive Statistics for Sample (FY 2001 to FY 2006)

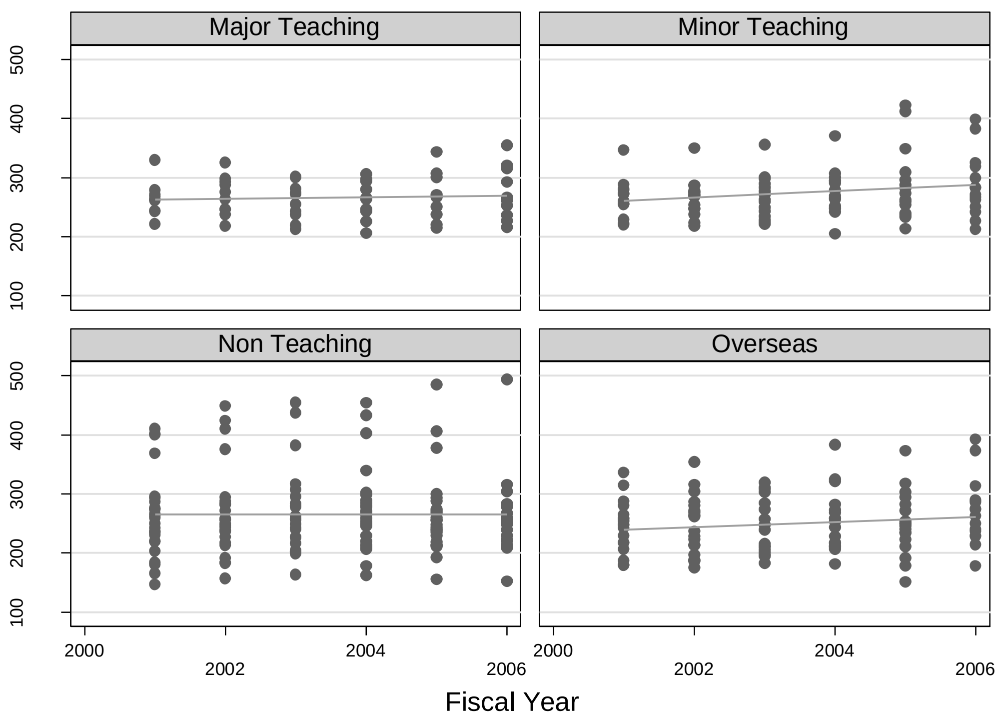
	M	SD	Min	Max	n
Level 1 Independent Variables (Time Varying)					
WOUND	0.20	1.24	0	14.72	407
RN	6.42	2.74	0.34	18.06	407
CLIN	9.16	4.65	2.74	36.30	407
DEPLOY	8.13	11.30	0	88.07	407
CONTRACT	0.78	1.20	0	9.85	407
CMI	0.74	0.25	0.38	1.66	407
Level 2 Independent Variables (Time Invariant)					
AF	0.28				
NAVY	0.33				
(Army-Referent)	0.39				
MINOR	0.22				
NON	0.37				
OS	0.27				
(Major-Referent)	0.14				
Dependent Variables[a]					
PROD	263.18	55.24	146.52	493.52	407
IQI 20	2.71	3.83	0	18	263
IQI 23	41.06	30.60	10	161	230
IQI 33	95.92	95.33	0	587	346
PSI 1	0.34	0.90	0	8	407
PSI 3	6.49	12.22	0	82	362
PSI 12	4.34	10.06	0	75	405
PSI 14	0.40	0.85	0	6	372
PSI 15	10.20	16.82	0	83	407

Note. [a] Observations are excluded if hospitals in a specific year did not have at least 15 patients at risk for the quality indicator. Some quality indicators have sample sizes less than 407 for the mixed effects model.

Table 7 also shows that in the total sample of 407 hospital observations, 28% were Air Force (AF), 33% were Navy and 39% were Army. The annual productivity (PROD) of these military hospitals varies greatly. Although the average productivity is 263.18 RWPs per 1000 bed days, the range is from 146.52 RWPs to 493.52 RWPs per 1000 bed days. Interestingly, both the lowest and highest productivity values are for non-teaching hospitals. The difference in productivity seems to be unrelated to the type of hospital.

Figure 5 illustrates that the average RWPs per 1000 bed days are similar for all four types of hospitals, but non-teaching hospitals have the greatest variability in productivity. Most of the observations for hospital productivity fall between 200 and 400 RWPs, but many non-teaching hospitals have productivity values that fall below 200 or above 400 RWPs. The variability in productivity for major teaching hospitals is the smallest among the different types of hospitals. The average trend for each type of hospital was constant or slightly increased (Figure 5). The trend for overseas hospitals may have been influenced by the productivity for Landstuhl Regional Medical Center, which increased dramatically after the invasion of Iraq in 2003 because all wounded service members from Iraq and Afghanistan were evacuated to Landstuhl to be stabilized before being evacuated to the continental United States.

Figure 5. Scatterplot and Trend of Productivity over Time by Type of Hospital.



With respect to the quality variables in Table 7, all hospitals had patients at risk for only two of the quality indicators, PSI 1 (Complications of Anesthesia) and PSI 15 (Accidental Puncture or Laceration). The number of hospitals with patients at risk for the rest of the quality indicators (IQI 20, IQI 23, IQI 33, PSI 3, PSI 12, and PSI 14) differed with the fewest hospital observations (230) for laparoscopic cholecystectomy (IQI 23) and the most hospital observations (405) for postoperative pulmonary embolism or deep vein thrombosis (DVT, PSI 12). Observations were excluded if hospitals in a specific year did not have enough patients at risk (less than 15 patients) for the quality indicator, thereby accounting for sample sizes less than 407 in Table 7.

Summary statistics are presented in Table 8 by type of hospital. Reinforcing the graphs in Figure 5, Table 8 shows that the average productivity is similar regardless of teaching status. The average productivity across the six years of the study for major, minor and non-teaching hospitals ranged from 264.94 to 274.46 RWPs per 1000 bed days. Overseas hospitals' average productivity was slightly lower at about 250 RWPs. However, for the quality indicators, there were big differences between the average adverse events for major teaching hospitals when compared to the average for non-teaching and overseas hospitals. In particular, major teaching hospitals had an average number of observed adverse events in the 20s for PSI 3 (Decubitus Ulcer) and PSI 12 (Postoperative Pulmonary Embolism or DVT) while the average number of adverse events were less than 1 for non-teaching and overseas hospitals. Also of note are the relatively few number of overseas hospital observations for IQI 20 (Pneumonia Mortality) and IQI 23 (Laparoscopic Cholecystectomy), n=22 and n=28, respectively.

Summary statistics are also presented in Table 9 by branch of service. For productivity, all three services produce comparable average RWPs per 1000 bed days, but the Air Force

Table 8
Descriptive Statistics for Dependent Variables by Type of Hospital

	Major Teaching			Minor Teaching			Non-Teaching			Overseas		
	M	SD	n	M	SD	n	M	SD	n	M	SD	n
PROD	266.16	34.54	60	274.46	43.44	89	264.94	69.20	149	249.92	49.29	109
IQI 20	7.83	3.79	60	2.15	2.80	87	0.43	1.12	94	0.73	0.98	22
IQI 23	64.93	36.76	60	41.29	26.83	78	21.83	9.39	64	33.18	22.90	28
IQI 33	258.88	145.84	42	116.28	76.99	89	69.71	33.27	112	40.39	26.58	103
PSI 1	1.27	1.65	60	0.44	0.89	89	0.11	0.37	149	0.07	0.30	109
PSI 3	28.03	15.68	60	5.87	6.75	89	0.59	0.97	137	0.83	1.56	76
PSI 12	23.18	15.46	60	2.81	3.68	89	0.54	0.92	149	0.35	0.90	107
PSI 14	1.38	1.39	60	0.42	0.67	89	0.15	0.47	147	0.09	0.29	76
PSI 15	41.87	22.29	60	10.08	8.01	89	3.18	3.38	149	2.46	6.18	109

Table 9
Descriptive Statistics for Dependent Variables by Branch of Service

	Army			Air Force			Navy		
	M	SD	n	M	SD	n	M	SD	n
PROD	261.60	51.39	160	280.84	73.84	113	250.17	33.59	134
IQI 20	2.96	4.22	122	3.13	4.16	64	1.97	2.66	77
IQI 23	39.24	27.39	114	31.41	16.69	61	55.53	42.03	55
IQI 33	102.66	78.69	131	64.84	38.52	92	112.01	130.22	123
PSI 1	0.48	0.90	160	0.17	0.53	113	0.32	1.10	134
PSI 3	7.52	13.76	160	5.14	7.63	93	6.12	12.94	109
PSI 12	6.24	13.53	160	3.03	6.07	113	3.17	7.15	132
PSI 14	0.42	0.91	159	0.36	0.78	99	0.40	0.83	114
PSI 15	13.71	19.04	160	6.54	8.17	113	9.09	18.61	134

hospitals (M=280.84) have slightly higher average productivity than hospitals in its sister services. Unlike some of the average differences when grouped by type of hospital, there are no glaring average differences in quality indicators when grouped by branch of service. In general, Air Force hospitals have fewer average adverse events than Army and Navy hospitals.

Since longitudinal data are unlikely to be independent, intraclass correlation coefficients (ICC) were estimated to determine the strength of the nonindependence. The ICC (ρ) gives an

indication of the proportion of variance in each dependent variable that lies between hospitals and may be explained by the characteristics of the organization (Singer & Willett, 2003). The high ICCs listed in Table 10 demonstrate that most of the variance lies between hospitals. The variance between hospitals is generally much greater than the variance within hospitals at different time periods for most of the dependent variables in Table 10. For productivity, $\rho = .841$, meaning that 84.1% of the total variation was due to differences between hospitals which may be attributable to hospital level characteristics. Only complications of anesthesia (PSI 1) and postoperative wound dehiscence (PSI 14) have ICCs close to the 0.5 range, meaning that there is about as much variance within hospitals from year to year as there is between hospitals for PSI 1 and PSI 14. In the summary statistics by type of hospital shown in Table 8, the range of average observed adverse events for PSI 1 and PSI 14 is between 0.07 and 1.38, which are extremely low numbers of observed adverse events for these patient safety indicators and explains why there may be as much variation between hospitals as there is within hospitals. When ICCs are low, a multilevel model may not be necessary because there is only a small proportion of the variance that is accounted for by differences in the higher level units, in this case difference between hospitals.

Table 11 depicts the change in time varying (Level 1) independent variables over the six years studied. The average percentage of wounded discharges (WOUND) and the average percentage of deployed staff (DEPLOY) increase after the wars in Iraq began in FY 2003. There is also a corresponding increase in the average number of contractor FTEs (CONTRACT) since 2003. The average number of nurses (RN) and clinicians (CLIN) do not show a clear pattern corresponding to the FY2003 start of the War in Iraq.

Table 10
Variance and Intraclass Correlation Coefficients for Dependent Variables

Outcome Variable	Variable Description	Between Variance	Within Variance	ICC (ρ)
PROD	RWP Adjusted Discharges per 1000 Bed Days	2724.01	514.83	0.8410
IQI 20	Pneumonia Mortality Rate	11.33	3.25	0.7773
IQI 23	Laparoscopic Cholecystectomy Rate	788.28	125.45	0.8627
IQI 33	Primary Cesarean Delivery Rate	8701.00	397.71	0.9563
PSI 1	Complications of Anesthesia	0.43	0.37	0.5326
PSI 3	Decubitus Ulcer	131.20	14.45	0.9008
PSI 12	Postop Pulmonary Embolism or DVT	92.85	6.70	0.9327
PSI 14	Postop Wound Dehiscence	0.31	0.40	0.4368
PSI 15	Accidental Puncture or Laceration	253.46	26.94	0.9039

Table 11
Descriptive statistics for independent variables over six fiscal years

Fiscal	WOUND		DEPLOY		CONTRACT		RN		CLIN	
Year	M	SD	M	SD	M	SD	M	SD	M	SD
2001	0.00	0.00	1.24	1.85	0.56	1.31	5.97	2.43	8.94	4.15
2002	0.00	0.00	3.26	4.19	0.60	1.15	6.14	2.58	9.25	4.62
2003	0.12	0.70	10.30	10.52	0.80	1.12	6.41	2.88	9.37	4.82
2004	0.31	1.69	8.60	11.05	0.89	1.20	6.56	3.09	9.53	5.61
2005	0.40	1.88	10.56	10.40	0.90	1.14	6.49	2.77	9.06	4.51
2006	0.39	1.61	15.96	17.25	0.98	1.23	7.01	2.62	8.76	4.10

Correlation analysis of the independent and dependent variables was conducted to ensure there was not excessive collinearity among the variables in the models. Correlation coefficients greater than 0.5 were considered highly correlated. Table 12 depicts the correlation matrix for the independent variables. Only nurse staffing (RN) and clinician staffing (CLIN) were highly correlated (r = 0.65), which makes sense that hospitals that have more inpatients will have both

Table 12

Correlation Matrix of Independent Variables

	TIME	WOUND	RN	CLIN	DEPLOY	CONTRACT	CMI	AF	NAVY	MINOR	NON	OS	AF x TIME	NAVY x TIME	MINOR x TIME	NON x TIME	OS x TIME
TIME	1																
WOUND	0.130*	1															
RN	0.112	-0.079	1														
CLIN	-0.011	-0.168*	0.652*	1													
DEPLOY	0.399*	0.021	-0.034	-0.209*	1												
CONTRACT	0.125	-0.019	0.084	0.043	0.107	1											
CMI	-0.007	0.244*	-0.104	-0.087	-0.026	0.163*	1										
AF	-0.026	-0.094	-0.140*	0.381*	-0.190*	-0.141*	0.041	1									
NAVY	0.006	-0.076	0.275*	0.079	-0.318*	-0.025	-0.213*	-0.434*	1								
MINOR	0.012	-0.073	-0.176*	-0.114	0.044	0.009	0.015	-0.023	0.009	1							
NON	-0.016	-0.103	0.110	0.151*	0.213*	0.181*	-0.256*	0.019	-0.153*	-0.402*	1						
OS	-0.007	0.115	0.243*	0.165*	-0.239*	-0.359*	-0.268*	0.059	0.178*	-0.320*	-0.460*	1					
AF x TIME	0.311*	-0.070	-0.038	0.334*	-0.110	-0.053	0.025	0.770*	-0.335*	-0.015	-0.003	0.055	1				
NAVY x TIME	0.379*	-0.043	0.202*	0.046	-0.169*	-0.032	-0.171*	-0.331*	0.763*	0.013	-0.119	0.129*	-0.255*	1			
MINOR x TIME	0.308*	-0.053	-0.096	-0.062	0.136*	0.056	0.016	-0.010	0.004	0.774*	-0.320*	-0.255*	0.099	0.116	1		
NON x TIME	0.384*	-0.066	0.141*	0.065	0.403*	0.204*	-0.213*	-0.008	-0.111	-0.302*	0.752*	-0.345*	0.115	0.018	-0.241*	1	
OS x TIME	0.322*	0.177*	0.211*	0.150*	-0.122	-0.281*	-0.196*	0.048	0.138*	-0.248*	-0.356*	0.774*	0.172*	0.275*	-0.197*	-0.268*	1

Note. *p<0.01

Table 13

Correlation Matrix of Independent Variables with Dependent Variables

	Dependent Variables								
	PROD	PSI 1	PSI 3	PSI 12	PSI 14	PSI 15	IQI 20	IQI 23	IQI 33
TIME	0.0789	0.0193	0.0135	0.0013	-0.1026	-0.0019	-0.0979	-0.0389	0.0589
WOUND	0.0321	0.078	0.0873	0.1501*	0.0499	0.2311*	-0.0116	0.1779*	0.0025
RN	0.3900*	-0.1742*	-0.3303*	-0.2585*	-0.2477*	-0.3080*	-0.2934*	-0.3250*	-0.3584*
CLIN	0.4531*	-0.2039*	-0.2941*	-0.2962*	-0.1998*	-0.3575*	-0.2838*	-0.3369*	-0.4303*
DEPLOY	0.0175	0.0029	-0.0766	-0.0447	-0.1124	-0.0316	-0.1279	-0.1253	0.0222
CONTRACT	0.1248	0.1163	0.2502*	0.1630*	0.1056	0.1726*	0.1919*	0.1942*	0.2060*
CMI	0.4575*	0.2775*	0.6649*	0.7092*	0.4768*	0.7001*	0.6753*	0.2449*	0.3494*
AF	0.1984*	-0.1198	-0.0649	-0.0814	-0.0262	-0.1351*	0.0614	-0.1898*	-0.1965*
NAVY	-0.1651*	-0.0161	-0.0197	-0.0813	0.0023	-0.0463	-0.1241	0.2657*	0.1255
MINOR	0.1082	0.057	-0.0291	-0.0809	0.0101	-0.0038	-0.1033	0.0056	0.1258
NON	0.0242	-0.1984*	-0.3770*	-0.2889*	-0.2392*	-0.3175*	-0.4461*	-0.3910*	-0.1905*
OS	-0.1453*	-0.1808*	-0.2390*	-0.2383*	-0.1844*	-0.2787*	-0.1569	-0.0961	-0.3798*
AF x TIME	0.2078*	-0.0921	-0.0337	-0.0766	-0.0235	-0.1029	-0.0079	-0.1656	-0.1412*
NAVY x TIME	-0.1361*	-0.0436	-0.0049	-0.0518	-0.0148	-0.0495	-0.1202	0.1846*	0.12
MINOR x TIME	0.1408*	0.0463	-0.0165	-0.0665	-0.0376	-0.0214	-0.1025	-0.0764	0.1057
NON x TIME	0.0179	-0.1229	-0.2812*	-0.2203*	-0.1981*	-0.2361*	-0.3571*	-0.3174*	-0.1353
OS x TIME	-0.0704	-0.1267	-0.1852*	-0.1795*	-0.1413*	-0.1981*	-0.1162	-0.0559	-0.2856*

Note. *p<0.01

greater numbers of nurses and clinicians to take care of those inpatients. Both variables were kept in the model. Table 13 lists the correlations of the independent variables to the dependent variables. Since each dependent variable was analyzed separately, there was no need to determine bivariate correlations among the dependent variables. Only case mix index (CMI) was highly correlated with some of the quality dependent variables (PSI 3, PSI 12, PSI 15, IQI 20) with a correlation coefficient greater than 0.5. The quality dependent variables were the number of observed events, and hospitals with higher case mix index may have more adverse events due to the higher acuity of their patients. However, in the Poisson regression model used for the quality dependent variables, an offset factor based on expected adverse events accommodates the raw number of observed events. Therefore, the variable CMI was retained in the quality models.

Mixed Effects Models

Productivity.

The analytic results of the random coefficient, multilevel mixed effects model for productivity are listed in Table 14. For time varying predictors, the percentage of wounded discharges ($\beta_{20} = 5.983$, $p<0.001$) and the number of clinician staffing ($\beta_{40} = 4.135$, $p<0.001$) was significantly associated with productivity at the initial time period, FY 2001. Since wounded discharges were defined as percent of wounded discharges to total discharges, a one percentage point increase in wounded discharges was associated with an increase of almost six RWPs per 1000 bed days. For staffing, a one unit increase in clinician staffing (1 FTE/1000 bed days) was associated with an increase of 4.135 RWP/1000 bed days. Military hospitals with higher percentage of wounded patients and more clinician staff had higher levels of productivity.

For time invariant variables, neither branch of service nor teaching status were significantly associated with productivity. However, overseas hospitals ($\beta_{05} = -46.94$, $p<0.01$)

Table 14

Multilevel Mixed Effects Model for Productivity

	Productivity	
	Coefficient	Std. Err.
INTERCEPT (β_{00})	237.711	14.342
TIME (β_{10})	1.456	2.619
WOUND (β_{20})	5.983***	1.757
RN (β_{30})	1.701	1.184
CLIN (β_{40})	4.135***	0.82
DEPLOY (β_{50})	-0.155	0.166
CONTRACT (β_{60})	-3.563	2.268
AF (β_{01})	1.730	12.727
NAVY (β_{02})	-8.220	12.066
MINOR (β_{03})	-12.252	16.733
NON (β_{04})	-26.428	15.474
OS (β_{05})	-46.94**	16.622
AF x TIME (β_{11})	1.140	2.469
NAVY x TIME (β_{12})	-5.336*	2.332
MINOR x TIME (β_{13})	5.240	2.741
NON x TIME (β_{14})	3.433	2.763
OS x TIME (β_{15})	2.295	2.922
Random Effects Parameters		
	Variance	Std. Err.
Slope (τ11)	33.5684	10.8119
Intercept (τ00)	1463.6690	309.2659
Covariance (τ01)	28.4129	41.2215
Level 1 Residual (σ^2)	364.9662	32.3247
Likelihood Ratio Test[a]	$\chi^2(3) = 380.62$***	
Observations (n)	407	
Hospitals (J)	70	

Note. [a] Likelihood Ratio Test compares current mixed effects model with standard linear regression with no random effects.
*p<0.05; **p<0.01; ***p<0.001

had significantly lower average productivity than major teaching hospitals. The significant result for the interaction of branch of service with time indicate that the rate of change differs for Navy hospitals (β_{12} = -5.336, $p<0.05$) when compared to Army hospitals even though the average rate of change in productivity over time (β_{10}) is not significant. Navy hospitals have 5.336 fewer RWP/1000 bed days for each year increase in time.

The random error components seem reasonable. Variance in the intercept (τ_{00}) is 1464 while the variance in the slope (τ_{11}) is 33.6. These error variances summarize between hospital variability in productivity change for initial status (TIME=0 or FY 2001) and growth rates after controlling for branch of service and type of hospital. The smaller the error variances, the more these time invariant variables account for changes in productivity over time. The large error variance in the intercept (τ_{00} = 1464) indicates that the organizational characteristics, branch of service and type of hospital, do not capture much of the variability in productivity between hospitals. There remains a lot of residual variance that may be explained by additional Level 2 predictors. The Level 1 residual variance (σ^2) of 365 summarizes the within hospital variability of productivity from each hospital's own time trend.

Quality.

Inpatient quality indicators.

Table 15 lists the results of the mixed effects Poisson regression for IQIs. The regression coefficients and corresponding standard errors for each IQI along with the exponentiated regression coefficients are presented. For pneumonia mortality (IQI 20), two variables were significant. First, clinician staffing (β_{40} = -0.08, $p<0.05$) was associated with lower pneumonia mortalities (IQI 20). An increase in clinician staffing of one unit (1 FTE/1000 bed days) is associated with 8% fewer pneumonia mortalities per year, holding all other variables constant.

Table 15

Multilevel Mixed Effects Models for Quality: Inpatient Quality Indicators

	IQI 20 Pneumonia Mortality		IQI 23 Laparoscopic Cholecystectomy		IQI 33 Primary Cesarean Delivery	
	Coefficient (SE	exp(coeff.)	Coefficient (SE	exp(coeff.)	Coefficient (SE	exp(coeff.)
TIME (β_{10})	-0.07 (0.05)	0.93	0.02 (0.01)	1.02	0.03 (0.02)	1.03
WOUND (β_{20})	-0.07 (0.06)	0.94	0.01 (0.01)	1.01	-0.01 (0.01)	0.99
RN (β_{30})	0.10 (0.05)	1.10	-0.01 (0.01)	0.99	0.004 (0.01)	1.00
CLIN (β_{40})	-0.08*(0.03)	0.92	-0.001 (0.01)	1.00	0.01 (0.01)	1.01
DEPLOY (β_{50})	-0.004 (0.01)	1.00	0.001 (0.002)	1.00	0.001 (0.001)	1.00
CONTRACT (β_{60})	-0.09 (0.08)	0.92	0.05*(0.02)	1.05	0.01 (0.01)	1.01
CMI (β_{70})	0.11 (0.31)	1.11	-0.17*(0.08)	0.84	0.2 (0.14)	1.22
AF (β_{01})	0.39 (0.22)	1.48	0.18**(0.06)	1.20	0.01 (0.07)	1.01
NAVY (β_{02})	-0.03 (0.22)	0.97	0.17**(0.05)	1.19	0.19**(0.07)	1.21
MINOR (β_{03})	-0.21 (0.2)	0.81	0.08 (0.06)	1.08	0.02 (0.09)	1.02
NON (β_{04})	0.11 (0.32)	1.12	0.09 (0.08)	1.09	0.11 (0.1)	1.12
OS (β_{05})	-0.67 (0.57)	0.51	0.29***(0.08)	1.34	0.07 (0.1)	1.07
AF x TIME (β_{11})	-0.11 (0.06)	0.89	0.001 (0.02)	1.00	0.01 (0.02)	1.02
NAVY x TIME (β_{12})	-0.01 (0.07)	0.99	-0.001 (0.02)	1.00	-0.02 (0.02)	0.98
MINOR x TIME (β_{13})	0.04 (0.05)	1.04	-0.01 (0.01)	0.99	0.002 (0.02)	1.00
NON x TIME (β_{14})	-0.22*(0.11)	0.80	-0.01 (0.02)	0.99	-0.01 (0.02)	0.99
OS x TIME (β_{15})	0.27 (0.15)	1.31	-0.03 (0.02)	0.97	0.01 (0.02)	1.01
Constant (β_{00})	0.14 (0.41)	1.16	-0.03 (0.11)	0.97	-0.53 (0.17)	0.59
Random Effects Parameters						
	Variance	Std. Err.	Variance	Std. Err.	Variance	Std. Err.
Slope (τ11)	<0.001	<0.001	<0.001	<0.001	0.002	0.001
Intercept (τ00)	0.043	0.041	0.002	0.002	0.031	0.008
Covariance (τ01)	-0.001	0.007	<0.001	<0.001	-0.004	0.002
Likelihood Ratio Test[a]	$\chi^2(3) = 7.01$		$\chi^2(3) = 0$		$\chi^2(3) = 478$***	
Observations (n)	263		230		346	
Hospitals (J)	47		42		59	

Note. [a] Likelihood Ratio Test compares current mixed effects model with standard Poisson regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

Second, the significant interaction between non-teaching hospitals and time ($\beta_{14} = -0.22$, $p<0.05$) indicates that non-teaching hospitals had a different rate of change than major teaching hospitals for pneumonia mortality. Other factors being constant, non-teaching hospitals had a 25% decline in pneumonia mortality per year while major teaching hospitals only had 6.8% decline in pneumonia mortality per year. However, since non-teaching hospitals had very low expected deaths per year, close to zero, this significant difference in rate of change may not be practically significant.

Four independent variables were significant for laparoscopic cholecystectomy (IQI 23). For contract staff ($\beta_{60} = 0.05$, $p<0.05$), a one unit increase in contract staff (1 FTE/1000 patient bed days) is associated with 5% increase in laparoscopic cholecystectomies per year. It is interesting to note that both Air Force ($\beta_{01} = 0.18$, $p<0.01$) and Navy hospitals ($\beta_{02} = 0.17$, $p<0.01$) have about 20% higher number of laparoscopic cholecystectomies than Army hospitals. Overseas hospitals ($\beta_{05} = 0.29$, $p<0.001$) also have 34% higher number of laparoscopic cholecystectomy than major teaching hospitals in the United States.

The only other service difference was found in primary cesarean section deliveries (IQI 33). Navy hospitals ($\beta_{02} = 0.19$, $p<0.01$) had 21% more primary cesarean section deliveries than Army hospitals. This was the only significant variable for IQI 33.

Patient safety indicators.

The results of the mixed effects Poisson regression for patient safety indicators are displayed in Table 16. Similar to IQIs, the regression coefficients, standard errors and exponentiated regression coefficients for each PSI are presented. There are also some patient safety indicators that have unusually large estimates for the variables OS and NON. They will be explained after discussion of the significant estimates for PSIs.

Table 16

Multilevel Mixed Effects Models for Quality: Patient Safety Indicators

	PSI 1 Complications of Anesthesia		PSI 3 Decubitus Ulcer		PSI 12 Postop PE or DVT		PSI 14 Postop Wound Dehiscence		PSI 15 Accidental Puncture or Laceration	
	Coefficient (SE)	exp(coeff.)	Coefficient (SE)	exp(coeff.)	Coefficient (SE)	exp(coeff.)	Coefficient (SE)	exp(coeff.)	Coefficient (SE)	exp(coeff.)
TIME (β_{10})	0.07 (0.13)	1.07	0.04 (0.04)	1.04	0.06 (0.04)	1.06	-0.21 (0.11)	0.81	0.01 (0.04)	1.01
WOUND (β_{20})	0.03 (0.09)	1.03	-0.03 (0.03)	0.97	-0.01 (0.03)	0.99	0.04 (0.08)	1.04	0.00 (0.02)	1.00
RN (β_{30})	-0.09 (0.12)	0.92	-0.04 (0.04)	0.96	-0.06 (0.04)	0.94	-0.18* (0.08)	0.84	0.05 (0.03)	1.05
CLIN (β_{40})	0.09 (0.07)	1.10	0.01 (0.03)	1.01	0.00 (0.03)	1.00	0.03 (0.04)	1.03	-0.03 (0.02)	0.97
DEPLOY (β_{50})	-0.01 (0.02)	0.99	0.00 (0.00)	1.00	0.00 (0.01)	1.00	-0.01 (0.02)	0.99	0.00 (0.00)	1.00
CONTRACT (β_{60})	-0.02 (0.18)	0.99	-0.08 (0.07)	0.93	-0.11 (0.07)	0.90	0.20* (0.1)	1.22	-0.05 (0.05)	0.96
CMI (β_{70})	-0.45 (1.11)	0.64	0.15 (0.37)	1.17	0.92*(0.4)	2.51	0.58 (0.46)	1.79	0.08 (0.36)	1.08
AF (β_{01})	-0.85 (0.79)	0.43	-0.36 (0.29)	0.70	0.35 (0.25)	1.42	-0.51 (0.41)	0.60	-0.06 (0.24)	0.94
NAVY (β_{02})	-0.49 (0.73)	0.61	-0.17 (0.28)	0.84	0.20 (0.25)	1.22	0.30 (0.36)	1.34	-0.2 (0.24)	0.82
MINOR (β_{03})	-0.69 (0.81)	0.50	-0.11 (0.28)	0.89	-0.53 (0.27)	0.59	0.41 (0.36)	1.50	0.04 (0.29)	1.04
NON (β_{04})	-2.23*(1.08)	0.11	-0.87*(0.38)	0.42	-0.55 (0.36)	0.58	0.84 (0.5)	2.31	-0.36 (0.33)	0.70
OS (β_{05})	-2.13 (1.17)	0.12	-0.39 (0.41)	0.68	-1.64***(0.46)	0.19	0.37 (0.72)	1.44	-1.25**(0.38)	0.29
AF x TIME (β_{11})	-0.13 (0.19)	0.88	0.06 (0.06)	1.06	-0.07 (0.05)	0.93	0.28*(0.14)	1.32	0.05 (0.05)	1.05
NAVY x TIME (β_{12})	-0.14 (0.18)	0.87	0.00 (0.06)	1.00	-0.01 (0.05)	0.99	0.17 (0.13)	1.19	0.00 (0.05)	1.00
MINOR x TIME (β_{13})	0.09 (0.16)	1.09	0.04 (0.04)	1.04	0.02 (0.05)	1.02	0.00 (0.12)	1.00	-0.04 (0.05)	0.96
NON x TIME (β_{14})	0.41 (0.22)	1.51	0.04 (0.08)	1.04	-0.08 (0.08)	0.92	-0.01 (0.16)	0.99	-0.01 (0.06)	0.99
OS x TIME (β_{15})	0.36 (0.26)	1.43	0.01 (0.1)	1.01	0.13 (0.11)	1.14	0.05 (0.25)	1.05	0.16*(0.07)	1.17
Constant (β_{00})	-0.09 (1.38)	0.91	0.1 (0.49)	1.11	-0.75 (0.51)	0.47	0.65 (0.63)	1.91	0.38 (0.46)	1.46
Random Effects Parameters										
	Variance	Std. Err.	Variance	Std. Err.	Variance	Std. Err.	Variance	Std. Err.	Variance	Std. Err.
Slope (τ11)	0.027	0.027	0.008	0.004	0.002	0.003	<0.001	<0.001	0.012	0.004
Intercept (τ00)	1.412	0.659	0.364	0.136	0.174	0.105	<0.001	<0.000	0.375	0.115
Covariance (τ01)	-0.130	0.121	-0.043	0.022	-0.003	0.015	<-0.001	<0.001	-0.035	0.019
Likelihood Ratio Test[a]	$\chi^2(3) = 53.70$***		$\chi^2(3) = 160.74$***		$\chi^2(3) = 19.21$***		$\chi^2(3) = 0$		$\chi^2(3) = 379.41$***	
Observations (n)	407		362		405		372		407	
Hospitals (J)	70		64		70		66		70	

Note. [a] Likelihood Ratio Test compares current mixed effects model with standard Poisson regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

For both complications of anesthesia (PSI 1) and decubitus ulcer (PSI 3), only the coefficient for non-teaching hospital was significant. The estimates imply that non-teaching hospitals (PSI 1: $\beta_{04} = -2.23$, $p<0.05$; PSI 3: $\beta_{04} = -0.87$, $p<0.05$) have 89% fewer complications of anesthesia and 58% fewer instances of decubitus ulcer than major teaching hospitals. When compared to medical centers in the United States, the estimates imply that overseas hospitals ($\beta_{05} = -1.64$, $p<0.001$) had 81% fewer cases of postoperative pulmonary embolism or deep vein thrombosis (DVT) (PSI 12).

RN staffing ($\beta_{30} = -0.18$, $p<0.05$) was only associated with postoperative wound dehiscence (PSI 14). An increase in RN staffing by one unit (1 FTE/1000 bed days) was associated with a 16% decrease in postoperative wound dehiscence incidents. Conversely, an increase in contract staffing ($\beta_{60} = 0.20$, $p<0.05$) by one unit (1 FTE/1000 bed days) was associated with a 22% increase in postoperative wound dehiscence incidents. Finally, the time trend for Air Force hospitals ($\beta_{11} = 0.28$, $p<0.05$) is significantly different from that for Army hospitals. Estimates imply that postoperative wound dehiscence incidents for Army hospitals decrease 18.8% per year while incidents for overseas hospitals increase 8% per year.

Again, the estimates for overseas hospitals are extreme for accidental puncture or laceration (PSI 15: $\beta_{05} = -1.25$, $p<0.01$). The estimates imply that overseas hospitals have 71% fewer adverse events than major teaching hospitals for PSI 15. Overseas hospitals also had a significantly different rate of change (slope) than major teaching hospitals for accidental puncture ($\beta_{15} = 0.16$, $p<0.05$). Adverse events for major teaching hospitals only increase 1% per year while adverse events for overseas hospitals increase 19% per year.

For the time varying staffing variables, an increase in RN staffing [PSI 14: $\exp(\beta_{30}) = .84$] and clinician staffing [IQI 20: $\exp(\beta_{40}) = .92$] was associated with a decrease in adverse

events, postoperative wound dehiscence (PSI 14) and pneumonia mortality (IQI 20), respectively. However, an increase in contract staffing was associated with increased adverse events in laparoscopic cholecystectomy [IQI 23: exp (β_{60}) = 1.05] and postoperative wound dehiscence [PSI 14: exp (β_{60}) = 1.22].

For some of the quality indicators, especially patient safety indicators, there are unusually large (in absolute value) estimates for overseas hospitals (OS) and non-teaching hospitals (NON). One of the main reasons for the large estimates is due to the very small number of observed and expected incidents for overseas and non-teaching military hospitals. For example, for IQI 20 (pneumonia mortality), the total number of observed and expected incidents per year for all overseas hospitals is very small (ranging from 1 to 5 observed incidents and 2.2 to 2.7 expected incidents). In contrast, major teaching hospitals have much higher total numbers (ranging from 55 to 90 observed incidents and 74.3 to 93.3 expected incidents). For PSI 1 (complications of anesthesia) and PSI 14 (postoperative wound dehiscence), the same pattern of very small observed and expected total incidents per year are evident when looking at the total sum by group. For PSI 1, non-teaching hospitals (observed range: 0-5 incidents; expected range: 5.7-6.8 incidents) along with overseas hospitals show the same pattern of low adverse event incidence.

In other instances, such as PSI 12 (postoperative pulmonary embolism or DVT) and PSI 15 (accidental puncture or laceration), a few hospitals with high number of events mask the true pattern of low observed and expected incidences of the majority of the hospitals. Figure 6 and Figure 7 graph the observed and expected adverse events by hospital over time for PSI 12 and PSI 14, respectively. Initially, the total number of observed and expected incidences seem to be moderate in size, but if Hospitals 53, 55, 60 and 61 are excluded in Figure 6, the rest of the

Figure 6. PSI 12 Observed and Expected Numbers by Hospital per Year

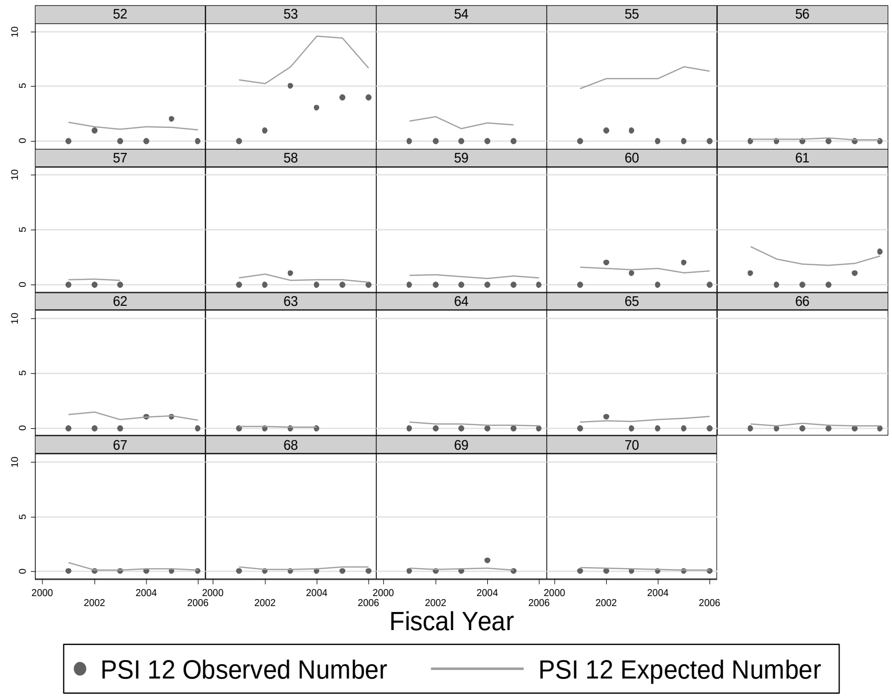
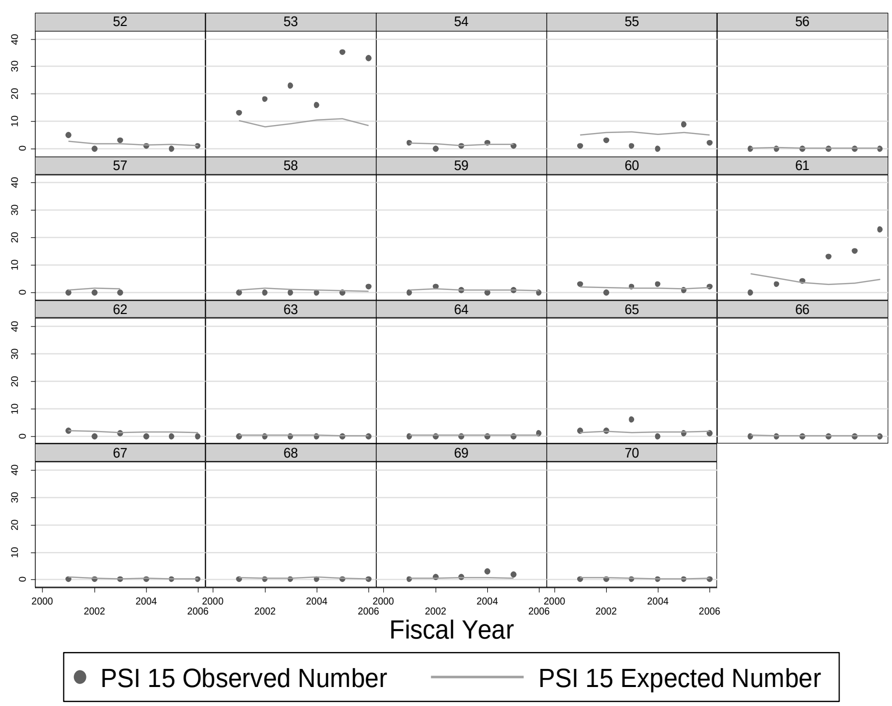


Figure 7. PSI 15 Observed and Expected Numbers by Hospital per Year



hospitals follow the same pattern of low observed and expected number of postoperative pulmonary embolism or DVT (PSI 12). The same low numbers are evident in Figure 7 when Hospitals 53, 55, and 61 are excluded for accidental puncture or laceration (PSI 15).

The pattern of unusual differences in parameter estimates suggests that non-teaching and overseas hospitals may be different than major teaching hospitals. There may be coding or procedural differences or there may be genuine differences between these types of hospitals, or both. One explanation may be that major teaching hospitals are where most of the clinical specialists are located, so they tend to treat more complex patients and have higher acuity surgical case loads. Non-teaching hospitals would send these complex cases to the major teaching hospitals in the MHS or to the civilian network. The more complex surgical cases would result in longer length of stay and potentially greater number of in-hospital interventions. Both of these possibilities may contribute to a greater opportunity for adverse events. Another explanation may be that the patient population served by major teaching hospitals is older and closer to the patient population of civilian hospitals versus the patient population at overseas hospitals, which would most likely be composed of active duty service members and their spouses and children. Overseas hospitals would likely not have many seniors over 65 years in the patient mix. Older patients may be more susceptible to having these adverse events or be admitted with preexisting conditions. In addition, the results also suggest that classifying overseas hospitals as a separate subset of non-teaching hospitals may not have been necessary.

Sensitivity Analyses

Two sensitivity analyses were conducted. The first sensitivity check was conducted after deleting the control variable overseas (OS) which was used to identify military hospitals in foreign countries. Some of the estimates for non-teaching and overseas hospitals (PSI 1, PSI 12,

PSI 15 from Table 16) were much larger in absolute value than reasonably expected, and there were relatively few overseas hospital observations for some of the inpatient quality indicators (IQI 23 and IQI 33 from Table 8). Since all overseas hospitals were non-teaching hospitals, the type of hospital was identified by three dummy variables (MINOR, NON, OS) to delineate teaching status and overseas status combined. By deleting the variable OS, type of hospital simply represents teaching status, and teaching status is identified by two dummy variables (MINOR and NON). Multilevel mixed effects models were conducted after classifying overseas hospitals as non-teaching hospitals. The second sensitivity analysis used fixed effects models instead of mixed effects models to constrain slopes and intercepts by groups created by the structural variables. The extreme values for some of the mixed effects model coefficients, along with evidence from the likelihood ratio test indicating that adding random slope and intercept for IQI 20, IQI 23 and PSI 14 did not significantly improve the model, was the rationale for the fixed effects model methodology. In the fixed effect model, all time invariant variables (e.g., service and teaching status) are subsumed in the fixed effect; therefore, parameters for these variables cannot be estimated.

Productivity sensitivity analyses.

Classification of overseas hospitals as non-teaching hospital.

The results comparing all three productivity models (original multilevel mixed effects model, multilevel mixed effects model without the variable OS, and fixed effects model) are presented in Table 17. The results for productivity after classifying overseas hospitals as non-teaching hospitals are very similar to the results from the model including the variable OS. The percent of wounded discharges ($\beta_{20} = 6.042$, $p<0.001$), clinician staffing ($\beta_{40} = 4.253$, $p<0.001$) and the interaction NAVY*TIME ($\beta_{12} = -4.974$, $p<0.05$) were again statistically significant as in

Table 17
Sensitivity Analysis for Productivity

	Mixed Effects Model	Mixed Effects Model without OS	Fixed Effects Model[a]
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
INTERCEPT (β_{00})	237.71 (14.34)	238.94 (14.44)	220.29 (6.64)
TIME (β_{10})	1.46 (2.62)	2.52 (2.10)	0.64 (2.00)
WOUND (β_{20})	5.98*** (1.76)	6.04*** (1.75)	6.99*** (1.44)
RN (β_{30})	1.70 (1.18)	1.45 (1.18)	1.56 (1.16)
CLIN (β_{40})	4.14*** (0.82)	4.25*** (0.82)	3.00*** (0.84)
DEPLOY (β_{50})	-0.16 (0.17)	-0.15 (0.17)	0.01 (0.17)
CONTRACT (β_{60})	-3.56 (2.27)	-3.22 (2.25)	-2.75 (2.49)
AF (β_{01})	1.73 (12.73)	-1.10 (12.75)	---
NAVY (β_{02})	-8.22 (12.07)	-12.64 (11.88)	---
MINOR (β_{03})	-12.25 (16.73)	-11.17 (16.91)	---
NON (β_{04})	-26.43 (15.47)	-33.55* (14.78)	---
OS (β_{05})	-46.94** (16.62)	---	---
AF x TIME (β_{11})	1.14 (2.47)	1.45 (2.43)	2.56 (1.87)
NAVY x TIME (β_{12})	-5.34* (2.33)	-4.97* (2.31)	-4.89** (1.74)
MINOR x TIME (β_{13})	5.24 (2.74)	4.07 (2.21)	5.06* (2.08)
NON x TIME (β_{14})	3.43 (2.76)	2.35 (2.13)	2.66 (2.02)
OS x TIME (β_{15})	2.23 (2.92)	---	2.55 (2.12)
Random Effects Parameters	Variance (SE)	Variance (SE)	
Slope (τ11)	33.57 (10.81)	33.58 (10.72)	---
Intercept (τ00)	1463.67 (309.27)	1503.17 (313.72)	---
Covariance (τ01)	28.41 (41.22)	26.12 (41.86)	---
Level 1 Residual (σ^2)	364.97 (32.33)	364.48 (32.23)	---
Likelihood Ratio Test[b]	$\chi^2(3) = 380.62$***	$\chi^2(3) = 384.00$***	---
F test	---	---	F (11, 326) = 11.7***
R^2	---	---	0.232
Observations (n)	407	407	407
Hospitals (J)	70	70	70

Note. [a] Level 2 time invariant variables are omitted.

[b] Likelihood ratio test compares mixed effects model with standard linear regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

the original mixed effects productivity model. Whereas the coefficient for overseas hospitals was significant in the original model, the coefficient for non-teaching hospitals ($\beta_{04} = 33.553$, $p<0.05$) was significant in the model without a separate variable for overseas hospitals.

Fixed effects models.

Table 17 also shows the fixed effects model for productivity. For time varying predictors, the same two variables significantly influenced productivity as the mixed effects model: the percentage of wounded discharges ($\beta_{20} = 6.994$, $p<0.001$) and the number of clinician staffing ($\beta_{40} = 3.003$, $p<0.001$). All of the time invariant variables representing teaching status, overseas hospital, and branch of service were omitted since there was no change in these independent variables over time. For the interactions between TIME and the structural variables, the interactions between MINOR and TIME ($\beta_{13} = 5.058$, $p<0.05$) and between NAVY and TIME ($\beta_{12} = -4.895$, $p<0.01$) were also significant. The difference in the productivity rate of change is evident for Navy hospitals when compared to Army hospitals, similar to the mixed effects models. However, the productivity rate of change for minor teaching hospitals increases significantly faster per year than major teaching hospitals in the fixed effects model.

Quality sensitivity analyses.

Classification of overseas hospitals as non-teaching hospital.

The results comparing all three quality models (original multilevel mixed effects model, multilevel mixed effects model without the variable OS, and fixed effects model) for each quality indicator are presented in Tables 18-21. For inpatient quality indicators, classifying all overseas hospitals as non-teaching hospitals changed very few of the coefficients (see Tables 18 and 19). Like the original multilevel mixed effects model, clinician staffing and the interaction of NONxTIME was significantly associated with pneumonia mortality (IQI 20, Table 18).

Table 18

Sensitivity Analysis for Quality: Inpatient Quality Indicators (IQI 20 and IQI23)

	IQI 20 Pneumonia Mortality						IQI 23 Laparoscopic Cholecystectomy					
	Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]		Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]	
	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)
TIME (β_{10})	-0.07 (0.05)	0.93	-0.07 (0.05)	0.93	-0.08* (0.04)	0.92	0.02 (0.01)	1.02	0.02 (0.01)	1.02	0.02 (0.01)	1.02
WOUND (β_{20})	-0.07 (0.06)	0.94	-0.06 (0.06)	0.94	-0.05 (0.06)	0.95	0.01 (0.01)	1.01	0.01 (0.01)	1.01	0.01 (0.01)	1.01
RN (β_{30})	0.10 (0.05)	1.10	0.10 (0.05)	1.10	0.16* (0.06)	1.17	-0.01 (0.01)	0.99	-0.01 (0.01)	0.99	-0.01 (0.01)	0.99
CLIN (β_{40})	-0.08*(0.03)	0.92	-0.08** (0.03)	0.92	0.03 (0.05)	1.03	0.00 (0.01)	1.00	-0.01 (0.01)	0.99	0.00 (0.01)	1.00
DEPLOY (β_{50})	-0.004 (0.01)	1.00	-0.003 (0.01)	1.00	0.00 (0.01)	1.00	0.00 (0.00)	1.00	0.001 (0.002)	1.00	0.00 (0.00)	1.00
CONTRACT (β_{60})	-0.09 (0.08)	0.92	-0.09 (0.08)	0.92	-0.15* (0.07)	1.16	0.05*(0.02)	1.05	0.04* (0.02)	1.04	0.05*(0.02)	1.05
CMI (β_{70})	0.11 (0.31)	1.11	0.11 (0.3)	1.11	-0.67 (0.99)	0.51	-0.17*(0.08)	0.84	-0.14 (0.08)	0.87	-0.17*(0.08)	0.84
AF (β_{01})	0.39 (0.22)	1.48	0.41 (0.22)	1.50	---		0.18**(0.06)	1.20	0.16* (0.06)	1.17	---	
NAVY (β_{02})	-0.03 (0.22)	0.97	-0.08 (0.22)	0.92	---		0.17**(0.05)	1.19	0.19*** (0.05)	1.21	---	
MINOR (β_{03})	-0.21 (0.2)	0.81	-0.20 (0.2)	0.82	---		0.08 (0.06)	1.08	0.09 (0.06)	1.10	---	
NON (β_{04})	0.11 (0.32)	1.12	0.09 (0.25)	1.10	---		0.09 (0.08)	1.09	0.19** (0.06)	1.21	---	
OS (β_{05})	-0.67 (0.57)	0.51	---		---		0.29***(0.08)	1.34	---		---	
AF x TIME (β_{11})	-0.11 (0.06)	0.89	-0.11 (0.06)	0.89	-0.14*** (0.04)	0.87	0.00 (0.02)	1.00	0.01 (0.02)	1.01	0.00 (0.02)	1.00
NAVY x TIME (β_{12})	-0.01 (0.07)	0.99	0.01 (0.06)	1.01	-0.01 (0.06)	0.99	0.00 (0.02)	1.00	-0.004 (0.02)	1.00	0.00 (0.02)	1.00
MINOR x TIME (β_{13})	0.04 (0.05)	1.04	0.04 (0.05)	1.04	0.03 (0.04)	1.03	-0.01 (0.01)	0.99	-0.01 (0.01)	0.99	-0.01 (0.01)	0.99
NON x TIME (β_{14})	-0.22*(0.11)	0.80	-0.21* (0.1)	0.80	-0.24 (0.16)	0.79	-0.01 (0.02)	0.99	-0.03* (0.02)	0.97	-0.01 (0.02)	0.99
OS x TIME (β_{15})	0.27 (0.15)	1.31	---		0.35** (0.11)	1.42	-0.03 (0.02)	0.97	---		-0.03 (0.02)	0.97
Constant (β_{00})	0.14 (0.41)	1.16	0.15 (0.41)	1.16	---		-0.03 (0.11)	0.97	-0.05 (0.11)	0.95	---	
Random Effects Parameters	Variance	Std. Err.	Variance	Std. Err.			Variance	Std. Err.	Variance	Std. Err.		
Slope (τ11)	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001		
Intercept (τ00)	0.043	0.041	0.043	0.040			0.002	0.002	0.003	0.003		
Covariance (τ01)	-0.001	0.007	-0.001	0.007			<0.001	<0.001	<-0.001	<0.001		
Likelihood Ratio Test[b]	$\chi^2(3) = 7.01$		$\chi^2(3) = 7.22$		---		$\chi^2(3) = 0$		$\chi^2(3) = 0$		---	
Wald	---		---		$\chi^2(12) = 228.86$***		---		---		$\chi^2(12) = 61.21$***	
Observations (n)	263		263		206		230		230		230	
Hospitals (J)	47		47		35		42		42		42	

Note. [a] Level 2 time invariant variables are omitted.

[b]Likelihood Ratio Test compares current mixed effects model with standard Poisson regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

Table 19

Sensitivity Analysis for Quality: Inpatient Quality Indicator (IQI 33) and Patient Safety Indicator (PSI 1)

	IQI 33 Primary Cesarean Delivery						PSI 1 Complications of Anesthesia					
	Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]		Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]	
	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)
TIME (β_{10})	0.03 (0.02)	1.03	0.03* (0.01)	1.03	0.03 (0.02)	1.03	0.07 (0.13)	1.07	0.12 (0.13)	1.13	0.21 (0.15)	1.23
WOUND (β_{20})	-0.01 (0.01)	0.99	-0.01 (0.01)	0.99	-0.01 (0.01)	0.99	0.03 (0.09)	1.03	0.07 (0.1)	1.07	-0.17 (0.12)	0.85
RN (β_{30})	0.00 (0.01)	1.00	0.003 (0.01)	1.00	0.00 (0.01)	1.00	-0.09 (0.12)	0.92	-0.06 (0.13)	0.94	-0.08 (0.15)	0.92
CLIN (β_{40})	0.01 (0.01)	1.01	0.01 (0.01)	1.01	0.01 (0.01)	1.01	0.09 (0.07)	1.10	0.07 (0.07)	1.07	0.10 (0.10)	1.11
DEPLOY (β_{50})	0.00 (0.00)	1.00	0.001 (0.001)	1.00	0.00 (0.00)	1.00	-0.01 (0.02)	0.99	-0.01 (0.02)	0.99	0.00 (0.02)	1.00
CONTRACT (β_{60})	0.01 (0.01)	1.01	0.01 (0.01)	1.01	0.01 (0.01)	1.01	-0.02 (0.18)	0.99	-0.07 (0.18)	0.93	-0.03 (0.21)	0.97
CMI (β_{70})	0.20 (0.14)	1.22	0.2 (0.14)	1.22	0.20 (0.14)	1.22	-0.45 (1.11)	0.64	-0.22 (1.13)	0.81	5.90*(2.99)	365.04
AF (β_{01})	0.01 (0.07)	1.01	0.004 (0.07)	1.00	---		-0.85 (0.79)	0.43	-0.79 (0.75)	0.45	---	
NAVY (β_{02})	0.19**(0.07)	1.21	0.19** (0.07)	1.20	---		-0.49 (0.73)	0.61	-0.33 (0.67)	0.72	---	
MINOR (β_{03})	0.02 (0.09)	1.02	0.02 (0.08)	1.02	---		-0.69 (0.81)	0.50	-0.41 (0.77)	0.66	---	
NON (β_{04})	0.11 (0.1)	1.12	0.09 (0.09)	1.10	---		-2.23*(1.08)	0.11	-1.48 (0.82)	0.23	---	
OS (β_{05})	0.07 (0.1)	1.07	---		---		-2.13 (1.17)	0.12	---		---	
AF x TIME (β_{11})	0.01 (0.02)	1.02	0.02 (0.02)	1.02	0.01 (0.02)	1.02	-0.13 (0.19)	0.88	-0.13 (0.19)	0.87	-0.36*(0.15)	0.70
NAVY x TIME (β_{12})	-0.02 (0.02)	0.98	-0.02 (0.02)	0.98	-0.02 (0.02)	0.98	-0.14 (0.18)	0.87	-0.17 (0.18)	0.84	-0.29 (0.17)	0.75
MINOR x TIME (β_{13})	0.0 (0.02)	1.00	0.001 (0.02)	1.00	0.00 (0.02)	1.00	0.09 (0.16)	1.09	0.01 (0.15)	1.01	-0.17 (0.16)	0.84
NON x TIME (β_{14})	-0.01 (0.02)	0.99	-0.01 (0.01)	0.99	-0.01 (0.02)	0.99	0.41 (0.22)	1.51	0.24 (0.16)	1.28	0.21 (0.23)	1.24
OS x TIME (β_{15})	0.01 (0.02)	1.01	---		0.01 (0.02)	1.01	0.36 (0.26)	1.43	---		0.22 (0.33)	1.25
Constant (β_{00})	-0.53 (0.17)	0.59	-0.52 (0.16)	0.59	---		-0.09 (1.38)	0.91	-0.47 (1.39)	0.62	---	
Random Effects Parameters	Variance	Std. Err.	Variance	Std. Err.			Variance	Std. Err.	Variance	Std. Err.		
Slope (τ11)	0.002	0.001	0.002	0.001			0.027	0.027	0.029	0.029		
Intercept (τ00)	0.031	0.008	0.032	0.008			1.412	0.659	1.250	0.570		
Covariance (τ01)	-0.004	0.002	-0.005	0.002			-0.130	0.121	-0.093	0.109		
Likelihood Ratio Test[b]	$\chi^2(3) = 478$***		$\chi^2(3) = 479$***		---		$\chi^2(3) = 53.70$***		$\chi^2(3) = 53.73$***		---	
Wald	---		---		$\chi^2(12) = 105.46$***		---		---		$\chi^2(12) = 88.52$***	
Observations (n)	346		346		346		407		407		185	
Hospitals (J)	59		59		59		70		70		31	

Note. [a] Level 2 time invariant variables are omitted.

[b]Likelihood Ratio Test compares current mixed effects model with standard Poisson regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

Table 20

Sensitivity Analysis for Quality: Patient Safety Indicators (PSI 3 and PSI 12)

	PSI 3 Decubitus Ulcer						PSI 12 Postoperative PE or DVT					
	Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]		Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]	
	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)
TIME (β_{10})	0.04 (0.04)	1.04	0.05 (0.04)	1.05	0.01 (0.05)	1.01	0.06 (0.04)	1.06	0.06 (0.04)	1.06	0.05 (0.04)	1.05
WOUND (β_{20})	-0.03 (0.03)	0.97	-0.03 (0.03)	0.97	-0.07**(0.02)	0.93	-0.01 (0.03)	0.99	-0.01 (0.03)	0.99	-0.03 (0.04)	0.97
RN (β_{30})	-0.04 (0.04)	0.96	-0.03 (0.04)	0.97	0.01 (0.06)	1.01	-0.06 (0.04)	0.94	-0.07 (0.04)	0.93	-0.01 (0.04)	0.99
CLIN (β_{40})	0.01 (0.03)	1.01	-0.004 (0.03)	1.00	-0.06 (0.03)	0.94	0.00 (0.03)	1.00	0.01 (0.03)	1.01	0.04 (0.03)	1.04
DEPLOY (β_{50})	0.00 (0.00)	1.00	-0.005 (0.004)	1.00	-0.01 (0.00)	0.99	0.00 (0.01)	1.00	0.003 (0.01)	1.00	0.00 (0.00)	1.00
CONTRACT (β_{60})	-0.08 (0.07)	0.93	-0.09 (0.07)	0.92	0.10 (0.13)	1.11	-0.11 (0.07)	0.90	-0.09 (0.07)	0.92	-0.11 (0.07)	0.90
CMI (β_{70})	0.15 (0.37)	1.17	0.20 (0.38)	1.22	-0.06 (0.84)	0.94	0.92*(0.4)	2.51	0.82 (0.42)	2.27	-0.45 (0.67)	0.64
AF (β_{01})	-0.36 (0.29)	0.70	-0.38 (0.29)	0.69	---		0.35 (0.25)	1.42	0.41 (0.27)	1.51	---	
NAVY (β_{02})	-0.17 (0.28)	0.84	-0.09 (0.28)	0.91	---		0.20 (0.25)	1.22	0.13 (0.27)	1.13	---	
MINOR (β_{03})	-0.11 (0.28)	0.89	-0.05 (0.28)	0.95	---		-0.53 (0.27)	0.59	-0.60* (0.3)	0.55	---	
NON (β_{04})	-0.87*(0.38)	0.42	-0.54 (0.3)	0.58	---		-0.55 (0.36)	0.58	-0.99** (0.32)	0.37	---	
OS (β_{05})	-0.39 (0.41)	0.68	---		---		-1.64***(0.46)	0.19	---		---	
AF x TIME (β_{11})	0.06 (0.06)	1.06	0.06 (0.06)	1.07	0.07 (0.05)	1.08	-0.07 (0.05)	0.93	-0.09 (0.05)	0.91	-0.09 (0.05)	0.92
NAVY x TIME (β_{12})	0.00 (0.06)	1.00	-0.005 (0.06)	1.00	0.02 (0.05)	1.02	-0.01 (0.05)	0.99	-0.01 (0.05)	0.99	0.00 (0.05)	1.00
MINOR x TIME (β_{13})	0.04 (0.04)	1.04	0.03 (0.04)	1.03	0.03 (0.04)	1.03	0.02 (0.05)	1.02	0.03 (0.05)	1.03	0.03 (0.05)	1.03
NON x TIME (β_{14})	0.04 (0.08)	1.04	-0.03 (0.06)	0.97	0.01 (0.07)	1.01	-0.08 (0.08)	0.92	0.003 (0.07)	1.00	-0.08 (0.08)	0.92
OS x TIME (β_{15})	0.01 (0.1)	1.01	---		0.06 (0.09)	1.06	0.13 (0.11)	1.14	---		0.20*(0.10)	1.22
Constant (β_{00})	0.1 (0.49)	1.11	0.02 (0.5)	1.02	---		-0.75 (0.51)	0.47	-0.69 (0.54)	0.50	---	
Random Effects Parameters	Variance	Std. Err.	Variance	Std. Err.			Variance	Std. Err.	Variance	Std. Err.		
Slope (τ11)	0.008	0.004	0.008	0.004			0.002	0.003	0.002	0.003		
Intercept (τ00)	0.364	0.136	0.372	0.137			0.174	0.105	0.256	0.132		
Covariance (τ01)	-0.043	0.022	-0.042	0.022			-0.003	0.015	-0.012	0.020		
Likelihood Ratio Test[b]	$\chi^2(3)$ = 160.74***		$\chi^2(3)$ = 163.61***		---		$\chi^2(3)$ = 19.21***		$\chi^2(3)$ = 31.29***		---	
Wald	---		---		$\chi^2(12)$ = 51.63***		---		---		$\chi^2(12)$ = 56.14***	
Observations (n)	362		362		291		405		405		290	
Hospitals (J)	64		64		50		70		70		49	

Note. [a] Level 2 time invariant variables are omitted.

[b]Likelihood Ratio Test compares current mixed effects model with standard Poisson regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

Table 21

Sensitivity Analysis for Quality: Patient Safety Indicators (PSI 14 and PSI 15)

	PSI 14 Postoperative Wound Dehiscence						PSI 15 Accidental Puncture or Laceration					
	Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]		Mixed Effects Model (with OS)		Mixed Effects Model (without OS)		Fixed Effects Model[a]	
	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)	Coeff. (SE)	exp(coeff.)
TIME (β_{10})	-0.21 (0.11)	0.81	-0.22 (0.11)	0.81	-0.16 (0.16)	0.85	0.01 (0.04)	1.01	0.03 (0.04)	1.03	0.03 (0.03)	1.03
WOUND (β_{20})	0.04 (0.08)	1.04	0.04 (0.07)	1.04	-0.01 (0.09)	0.99	0.00 (0.02)	1.00	0.01 (0.02)	1.01	-0.04 (0.03)	0.96
RN (β_{30})	-0.18* (0.08)	0.84	-0.18* (0.08)	0.83	-0.27 (0.19)	0.77	0.05 (0.03)	1.05	0.04 (0.03)	1.04	0.04 (0.05)	1.04
CLIN (β_{40})	0.03 (0.04)	1.03	0.03 (0.04)	1.03	0.09 (0.13)	1.10	-0.03 (0.02)	0.97	-0.02 (0.02)	0.98	0.00 (0.02)	1.00
DEPLOY (β_{50})	-0.01 (0.02)	0.99	-0.01 (0.02)	0.99	-0.01 (0.02)	0.99	0.00 (0.00)	1.00	0.001 (0)	1.00	0.00 (0.00)	1.00
CONTRACT (β_{60})	0.20* (0.1)	1.22	0.21* (0.1)	1.23	0.18 (0.18)	1.19	-0.05 (0.05)	0.96	-0.04 (0.05)	0.96	0.03 (0.08)	1.03
CMI (β_{70})	0.58 (0.46)	1.79	0.56 (0.46)	1.74	-0.03 (2.77)	0.97	0.08 (0.36)	1.08	0.08 (0.36)	1.09	0.20 (0.78)	1.22
AF (β_{01})	-0.51 (0.41)	0.60	-0.49 (0.41)	0.61	---		-0.06 (0.24)	0.94	-0.09 (0.25)	0.92	---	
NAVY (β_{02})	0.30 (0.36)	1.34	0.27 (0.36)	1.31	---		-0.2 (0.24)	0.82	-0.32 (0.24)	0.72	---	
MINOR (β_{03})	0.41 (0.36)	1.50	0.37 (0.35)	1.45	---		0.04 (0.29)	1.04	0.09 (0.3)	1.09	---	
NON (β_{04})	0.84 (0.5)	2.31	0.64 (0.4)	1.89	---		-0.36 (0.33)	0.70	-0.56 (0.3)	0.57	---	
OS (β_{05})	0.37 (0.72)	1.44	---		---		-1.25**(0.38)	0.29	---		---	
AF x TIME (β_{11})	0.28*(0.14)	1.32	0.27 (0.14)	1.32	0.31*(0.13)	1.32	0.05 (0.05)	1.05	0.04 (0.06)	1.04	0.03 (0.04)	1.03
NAVY x TIME (β_{12})	0.17 (0.13)	1.19	0.18 (0.13)	1.20	0.11 (0.18)	1.11	0.00 (0.05)	1.00	0.02 (0.06)	1.02	-0.03 (0.06)	0.97
MINOR x TIME (β_{13})	0.00 (0.12)	1.00	0.01 (0.12)	1.01	-0.06 (0.14)	0.94	-0.04 (0.05)	0.96	-0.05 (0.04)	0.95	-0.04 (0.04)	0.96
NON x TIME (β_{14})	-0.01 (0.16)	0.99	0.05 (0.13)	1.05	0.04 (0.15)	1.04	-0.01 (0.06)	0.99	0.01 (0.05)	1.01	0.00 (0.04)	1.00
OS x TIME (β_{15})	0.05 (0.25)	1.05	---		0.13 (0.33)	1.14	0.16*(0.07)	1.17	---		0.26*(0.11)	1.30
Constant (β_{00})	0.65 (0.63)	1.91	0.67 (0.63)	1.95	---		0.38 (0.46)	1.46	0.34 (0.46)	1.41	---	
Random Effects Parameters	Variance	Std. Err.	Variance	Std. Err.			Variance	Std. Err.	Variance	Std. Err.		
Slope (τ11)	<0.001	<0.001	<0.001	0.017			0.012	0.004	0.016	0.005		
Intercept (τ00)	<0.001	<0.000	0.003	0.208			0.375	0.115	0.427	0.128		
Covariance (τ01)	<-0.001	<0.001	<-0.001	0.059			-0.035	0.019	-0.048	0.023		
Likelihood Ratio Test[b]	$\chi^2(3) = 0$		$\chi^2(3) = 0$		---		$\chi^2(3) = 379.41$***		$\chi^2(3) = 398.27$***		---	
Wald	---		---		$\chi^2(12) = 15.36$***		---		---		$\chi^2(12) = 46.9$***	
Observations (n)	372		372		213		407		407		362	
Hospitals (J)	66		66		36		70		70		62	

Note. [a] Level 2 time invariant variables are omitted.

[b]Likelihood Ratio Test compares current mixed effects model with standard Poisson regression with no random effects.

*p<0.05; **p<0.01; ***p<0.001

There were a few differences for laparoscopic cholecystectomy (IQI 23, Table 18). Non-teaching hospitals (instead of overseas hospitals) significantly differ from major teaching hospitals in the number of adverse events, and the rate of change each year for non-teaching hospitals is slower than major teaching hospitals. For primary cesarean delivery (IQI 33, Table 19), the overall linear rate of change (TIME: $\beta_{10} = 0.03$, $p<0.05$) became statistically significant when overseas hospitals were combined into one group with non-teaching hospitals. For each additional year, the number of primary cesarean deliveries increases by 3% for Army major teaching hospitals.

For patient safety indicators overall, the unusually large (in absolute value) estimates decreased when comparing major teaching hospitals to non-teaching hospitals or overseas hospitals once all overseas hospitals were classified as non-teaching hospitals. The coefficients for non-teaching hospitals for complications of anesthesia (PSI 1, Table 19) and decubitus ulcer (PSI 3, Table 20) along with the coefficient for overseas hospitals for accidental puncture or laceration (PSI 15, Table 21) are not as extreme and are no longer statistically significant. Only postoperative pulmonary embolism or DVT (PSI 12, Table 20) resulted in a statistically significant difference between non-teaching hospitals (instead of overseas hospitals) and major teaching hospitals. Non-teaching hospitals ($\beta_{04} = -0.99$, $p<0.01$) had 63% fewer cases of postoperative pulmonary embolism or DVT than major teaching hospitals whereas overseas hospitals ($\beta_{05} = -1.64$, $p<0.001$) had 81% fewer cases of postoperative pulmonary embolism or DVT.

Fixed effects models.

The results of the fixed effects models for the quality dependent variables are shown in Tables 18 and 19 for inpatient quality indicators and Tables 19 - 21 for patient safety indicators.

For the inpatient quality indicators, the greatest difference between the original mixed effects model (including the variable OS) and the fixed effects model is for the dependent variable, pneumonia mortality (IQI 20, Table 18). Three of the time varying predictors (TIME, RN staffing and contract staffing) were statistically significant at $\alpha = 0.05$ while clinician staffing is no longer statistically significant. The rate of change for Air Force hospitals and overseas hospitals became significant while the rate of change for non-teaching hospitals is no longer significant. Since the likelihood ratio test ($\chi^2(3) = 7.01$, $p > 0.05$) from Table 15 showed that allowing the slopes and intercepts for each hospital to randomly vary over time (random intercepts and slopes) did not significantly improve the model, the results of the fixed effects model is most likely a better model for pneumonia mortality. The fixed effects coefficients estimated for laparoscopic cholecystectomy (IQI 23, Table 18) and primary cesarean delivery (IQI 33, Table 19) are essentially the same as those estimated in the mixed effects models.

For patient safety indicators, the number of observations and the number of hospitals in the fixed effects models are drastically different from the mixed effects models, especially for complications of anesthesia (PSI 1, Table 19) and accidental puncture or laceration (PSI 14, Table 21). If there were no observed adverse events for the dependent variable in all years, the hospital was excluded from the fixed effects model. Not surprisingly, many hospitals had zero observed adverse events even though the expected adverse events were greater than zero. Without variation in the dependent variable, these hospitals were dropped during the statistical analysis for the fixed effects models. The dependent variable complications of anesthesia (PSI 1, Table 19) had the biggest difference in observations and hospitals affected. The sample size decreased from 407 to 185, and the number of hospitals dropped from 70 to 31 in the fixed effects model. All of the coefficients are different, even changing the direction of the

relationship between the predictor and the dependent variable (e.g., WOUND). The mixed effects model may be a better model to use if it is reasonable to assume that none of regressors is correlated with the hospital structural variables (fixed effect). Although the mixed effects model includes all the hospitals in the sample and the addition of the random slopes and intercepts significantly improved the model when compared to a model without any random effects according to the likelihood ratio test ($\chi^2(3) = 53.70$, $p < .001$), it may not be reasonable to assume that the regressors are uncorrelated with the fixed effect.

For all five PSIs, only one time varying predictor (WOUND: PSI 3, Table 20) was statistically significant. The coefficients for RN staffing and contract staffing for postoperative wound dehiscence (PSI 14, Table 21) are no longer statistically significant in the fixed effects models. For PSI 14, the likelihood ratio test ($\chi^2(3) = 0$, $p > .05$) showed that allowing the slopes and intercepts for each hospital to randomly vary over time did not significantly improve the model; therefore, the fixed effects model may be a better model, but the number of observations decrease to 213 with only 36 hospitals out of 66 providing data for the fixed effects model. When sample sizes more closely correspond, the fixed effects models generally yield similar results as the mixed effects models.

Summary of Results

In summary, the structure of the hospital, whether it is an overseas hospital, hospital teaching status, or branch of armed service of the hospital, influenced productivity and certain quality indicators. The structural components were not able to reliably predict differences in productivity and all quality indicators. The wars in Iraq and Afghanistan, denoted by the variables for wounded discharges and deployed staff, were not significantly related to any of the quality indicators, and only the percentage of wounded discharges were significantly related to

the productivity of military hospitals. In essence, the war related jolt increased the workload and productivity of military hospitals, but it did not affect the quality provided in the hospitals, as measured by AHRQ inpatient and patient safety quality indicators. In the following chapter, these results are explored within the theoretical framework and study hypotheses. In addition, conclusions and implications are discussed.

Chapter 6: Discussion

The purpose of this research was to determine what impact the wars in Iraq and Afghanistan have had on the productivity and quality of United States military hospitals over the fiscal years 2001-2006. To determine how productivity and quality changed over the years, and to try to discern whether the trends differ by type of military hospital are the research questions addressed. Drawing on contingency theory, the jolt-related uncertainty arising from the wars in Iraq and Afghanistan, and its influence on productivity and quality of military hospitals were examined within the context of the structural characteristics of the hospitals. In this chapter, the findings of the tested hypotheses are discussed in relation to the impact on productivity and quality of military hospitals (see Table 22). Table 22 identifies which hypotheses were supported by the multilevel mixed effects models for productivity and quality. Study limitations, policy implications, and directions for future study are also addressed.

Productivity

Structural characteristics of hospitals, such as teaching status, were hypothesized to influence the level of productivity at military hospitals. The complexities of running graduate education programs and providing tertiary care are related to inertia in major teaching hospitals that makes change and adaptation to a new environment slower. Therefore, as stated in Hypothesis 3, major military teaching hospitals' rate of change in productivity would be slower than minor and non-teaching hospitals' rate of change in productivity. Hypothesis 3 is not

Table 22

Summary of Hypotheses Tested Categorized by Dependent Variable

Dependent Variable	Independent Variable (Construct)	Hypothesis	Hypothesis Supported?
Productivity			
	Teaching Status (Structure)	Hypothesis 3: Major teaching hospitals' rate of change in productivity will be slower than minor and non-teaching hospitals' rate of change in productivity.	Not supported (Table 14, β_{13}, β_{14})
	Branch of Service (Structure)	Hypothesis 5: Army hospitals' rate of change in productivity will be less rapid than Air Force and Navy hospitals' rate of change in productivity.	Not supported (Table 14, β_{11}, β_{12})
	Uncertainty (Deployed Staff)	Hypothesis 7: There will be an inverse relationship between proportion of deployed FTEs and productivity.	Not supported (Table 14, β_{50})
Quality			
IQI	Teaching Status (Structure)	Hypothesis 1: The average level of quality across the six years will be higher for major teaching hospitals than minor and non-teaching hospitals.	Not supported (Table 15, β_{03}, β_{04})
	Teaching Status (Structure)	Hypothesis 2: Major teaching hospitals' rate of change in quality will be slower than minor and non-teaching hospitals' rate of change in quality.	Some support IQI 20 (Table 15, β_{14})
	Uncertainty (Wounded Patient)	Hypothesis 4: There will be an inverse relationship between the percentage of wounded soldiers and quality.	Not supported (Table 15, β_{20})
	Branch of Service (Structure)	Hypothesis 6: Army hospitals' rate of change in quality will be less rapid than Air Force and Navy hospitals' rate of change in quality.	Not supported (Table 15, β_{11}, β_{12})
PSI	Teaching Status (Structure)	Hypothesis 1: The average level of quality across the six years will be higher for major teaching hospitals than minor and non-teaching hospitals.	Not supported (Table 16, $\beta_{03,}$ β_{04})
	Teaching Status (Structure)	Hypothesis 2: Major teaching hospitals' rate of change in quality will be slower than minor and non-teaching hospitals' rate of change in quality.	Not supported (Table 16, β_{13}, B_{14})
	Uncertainty (Wounded Patient)	Hypothesis 4: There will be an inverse relationship between the percentage of wounded soldiers and quality.	Not supported (Table 16, B_{20})
	Branch of Service (Structure)	Hypothesis 6: Army hospitals' rate of change in quality will be less rapid than Air Force and Navy hospitals' rate of change in quality.	Some support PSI 14 (Table 16, β_{11})

supported (see Table 22). The rate of productivity change for minor teaching hospitals and non-teaching hospitals did not differ significantly from major teaching hospitals in the military.

In addition, branch of armed services, another structural characteristic, was hypothesized to influence productivity (Hypothesis 5). Branch of service was also not found to be a significant factor in military hospitals' changes in productivity over the six years. Army hospitals' average rate of change in productivity was expected to be slower than Air Force and Navy hospitals' rate of change since the bulk of deployments were made by Army personnel. Navy hospitals' rate of change is negative while the rate of change for Army hospitals is slightly positive for productivity throughout the first five years of the wars in Iraq and Afghanistan. The productivity of Air Force and Navy hospitals declined on average each year which aligns with the trend in civilian hospitals to shift traditional inpatient care to the outpatient setting (Tanga et al., 2010; Cobourn et al., 2010).

As the wars in Iraq and Afghanistan waged on, staff deployments in support of operational medical support would influence military hospitals' productivity through staff turnover and vacancies. Hospitals with a high percentage of deployed FTEs were hypothesized to have lower productivity. Hypothesis 7 is not supported; there is no meaningful relationship between the percentage of deployed FTEs and hospital productivity. Although statistically significant, a corresponding 0.23% decrease in RWPs for each one percentage point increase in deployed FTEs is not relevant. Alexander and colleagues (1994) found that turnover disrupts the input/throughput/output cycle and reduces efficiency. Similar to the findings of O'Brien-Pallas and colleagues (2006) and Castle and Engberg (2005), there is evidence of decreased productivity as deployment creates an environment of increased turnover. However, the military hospitals are able to compensate for this turnover and possible inefficiency without decreasing

productivity in inpatient care. As organizations use resources to recruit, train, and team build, taking away resources away from production of healthcare services, the military hospitals may have processes in place to minimize the disruption. Since military personnel move every two to three years between bases routinely, military hospital leaders may already have policies and processes in place to accommodate turnover brought on by the wars in Iraq and Afghanistan.

Quality

Inpatient quality indicators.

Similar to productivity, structural characteristics of hospitals (teaching status and branch of service) were hypothesized to influence the level of quality at military hospitals after experiencing the jolt in uncertainty due to the conflicts. Hypothesis 1 was stated as: the average level of quality for all six years is higher for major teaching hospitals when compared to minor teaching hospitals and non-teaching hospitals. The mixed effects Poisson regression models for inpatient quality indicators results (Table 15) indicate that teaching status was not significantly associated with any inpatient quality indicators. Hypothesis 1 is not supported. There is no relationship between IQIs (pneumonia mortality, laparoscopic cholecystectomy and primary cesarean deliveries) and average level of quality when hospitals are stratified by teaching status. The evidence for teaching status is mixed. Studies have shown that major teaching hospitals have better quality in AMI but not necessarily in other quality indicators, such as pneumonia (Jha, et al., 2005). One reason may be that AMI mortality is more preventable with the appropriate treatment early on in the hospitalization than pneumonia and other conditions.

With reference to differing rates of change for major teaching hospitals in quality, results for only one IQI partially supported Hypothesis 2. Major teaching hospitals' rate of change was slower (slope closer to zero) than non-teaching hospitals' rate of change in pneumonia mortality

(IQI 20). For the most part, major teaching hospitals' rates of change in quality were not significantly different from minor and non-teaching hospitals. The expectation that major teaching hospitals would be slow to change their structure due to the complexity and rigidness of a more bureaucratic organization did not hold true for most of the inpatient quality indicators. It may be that all military hospitals are slow to change due to the inherent bureaucratic nature of being a military hospital with many rules and regulations and little flexibility at the local level. Another explanation may be that the emphasis on improving quality and better measurement in the hospital sector in general, both federal and non-federal hospitals, provided the impetus for military hospitals to try to obtain legitimacy by decreasing mortality incidences. Borzecki and colleagues (2010) noticed that VA mortality rates decreased for the following inpatient quality indicators, stroke, hip and pneumonia, across the years 2004 to 2007. The same trend may mask the structural differences normally expected utilizing Contingency Theory.

An inverse relationship was expected between the percentage of wounded soldiers and quality (Hypothesis 4). As the percentage of wounded soldiers increased, quality should decrease (more adverse events). Therefore, in order to find support for Hypothesis 4, as the percentage of wounded soldiers increased, it is expected that incidences of mortality and adverse events would increase. The percentage of wounded soldiers was not significantly associated with any inpatient quality indicators.

Senior management commitment in providing financial resources for quality improvement was identified as one of the factors that differentiated high versus low performing hospitals (Curry et al., 2011). With the increased attention for wounded warrior care, expenditures that could be directly related to the global war on terrorism were part of supplemental funding from Congress above and beyond the original budget of military hospitals.

The teaching hospitals that received the bulk of wounded soldiers would have documented expenditures related to the global war on terror. In the Inspector General report (2008), *Supplemental Funds Used for Medical Support for the Global War on Terrorism,* of the six military hospitals audited, the three teaching hospitals received a range of $22.89 to $35.97 million in additional funds while the three non-teaching hospitals received a range of $2.91 to 8.52 million in FY 2006. The additional financial resources may have provided the buffer to counter the expected decrease in quality due to the impact of war.

Although there were overall service differences for laparoscopic cholecystectomy (IQI 23) and primary cesarean delivery (IQI 33), there were no differences in rates of change in events over the six year period of the study among the services. Hypothesis 6 stated that Army hospitals' rate of change in quality would be less rapid than Air Force and Navy hospitals' rate of change in quality, but that expectation was not borne out in the study with regard to IQIs. Finally, the military hospitals tend to have a younger population of inpatients than civilian and VA hospitals since active duty and active duty family members have priority. Inpatient quality indicators that rely on mortality incidence may not be a good metric for quality in military hospitals. Possible other metrics may include 30 day readmission rates and appropriate follow up care coordination in the outpatient setting following hospital stays.

Patient safety indicators.

The patient safety models produced some significant statistical results (Table 16). Most of the statistically significant results were associated with type of hospital, teaching status and overseas status. In Hypothesis 1, the average level of quality for all six years was hypothesized to be higher for major teaching hospitals when compared to minor teaching hospitals and non-teaching hospitals. Non-teaching hospitals in the United States had lower incidence of adverse

events than major teaching hospitals in complications of anesthesia (PSI 1) and decubitus ulcer (PSI 3). Although teaching status differences were evident in these two PSIs, the direction was opposite what was hypothesized. Minor teaching hospitals had 89% fewer adverse events than major teaching hospitals in complications of anesthesia and 58% fewer adverse events in decubitus ulcer. When overseas hospitals are combined with non-teaching hospitals (Table 20, PSI 12: $\beta_{04} = -0.99$, $p<0.01$) non-teaching hospitals had 63% fewer incidences of postoperative pulmonary embolism and DVT than major teaching hospitals. These results align with the studies by Rivard and colleagues (2010) and Vartak and colleagues (2008) in which for some PSIs, major teaching hospitals had lower quality than non-teaching hospitals.

Both studies found that major teaching status was associated with greater likelihood of postoperative pulmonary embolism / DVT events, and Rivard and colleagues (2010) postulate that this indicator may be sensitive to conditions present on admission. Incorporating POA conditions drastically changes some patient safety indicators (Drosler et al., 2009; Houchens et al., 2008). Houchens and colleagues (2008) found that 54%–58% of previously identified postoperative pulmonary embolism/DVT events were no longer considered in-hospital patient safety events after accounting for POA conditions. POA indicators were not incorporated into the calculation of PSIs for this study, but POAs may have affected the results differently if they had been available. The differences between major teaching hospitals and minor and non-teaching hospitals may have decreased if POAs could have been incorporated into the study.

In addition, the Joint Commission emphasized venous thromboembolism (VTE) prevention and prophylaxis during the timeframe of the study. VTE is a combination of pulmonary embolism and DVT, and the emphasis on VTE prophylaxis may have decreased incidence in military hospitals in general since all military hospitals, including overseas

hospitals, must be accredited by the Joint Commission. However, due to the increased extremity injuries and orthopedic surgical cases from the wars in Iraq and Afghanistan, major teaching hospitals may have had increased opportunities for VTE when compared to non-teaching counterparts. Starting in 2009, measures for VTE prohylaxis is part of the core measure set for the Joint Commission's ORYX program (The Joint Commission, 2013).

Thus, this analysis found that the wars in Iraq and Afghanistan had almost no impact on productivity and quality of military hospitals over the years 2001-2006. None of the war related hypotheses (Hypothesis 4 and Hypothesis 7) were supported. Productivity and three quality indicators (IQI 20 Pneumonia Mortality; PSI 1 Complications of Anesthesia; PSI 3 Decubitus Ulcer) differ by the structural characteristic of teaching status in the hypothesized direction, and branch of service was only significantly related to productivity and one quality indicator (PSI 14 Postoperative Wound Dehiscence). Army, Navy and Air Force hospitals equally were able to adapt to the jolt of war and keep quality consistent throughout the years 2001 to 2006. Even though quality in military hospitals differs by teaching status, it is reassuring to see that the wars in Iraq and Afghanistan did not disproportionately burden major teaching hospitals and decrease their performance in quality. The military hospitals may be more agile than at first given credit, and they seem to have adapted to deploying staff and receiving increased wounded soldiers without increasing the incidence of adverse events as measured by AHRQ inpatient quality and patient safety indicators.

Strengths and Potential Contributions

This may be the first study of all military hospitals' performance analyzing certain measures of productivity and quality during a time of war. The study used longitudinal data over a six year period. This is also one of the few applications of contingency theory to a multilevel

modeling framework in military hospitals. The military hospitals did not show evidence of the initial decrease followed by increasing productivity and quality as anticipated utilizing structural contingency theory.

The ease of calculating AHRQ quality indicators using available administrative data makes them a good tool for monitoring inpatient quality and patient safety over time at each military hospital level. All military hospitals have at least one analyst who has access to data in the Military Health System Management Analysis and Reporting Tool (M2) to easily calculate AHRQ QIs to track at the local level. M2 is a subset of the MDR with fewer years and an easy to use Business Objects interface. Users of MDR must have SAS programming knowledge. The inclusion of present on admission (POA) data in the MDR in recent years improves the validity of the indicators, and POA should be used when tracking hospital performance in quality. Although military hospitals do not report to CMS and the *Hospital Compare* website, they tend to mimic the quality efforts of civilian hospitals. As such, the TRICARE Management Activity should initiate a policy for each Service medical activities to start tracking IQIs and PSIs since CMS has incorporated select indicators (4 PSIs, 2 IQIs, and 2 composites) into public reporting on *Hospital Compare*.

Limitations and Future Research

There are several limitations to this study. One limitation is that the current study could not incorporate data on conditions that were present on admission to the hospital. Although the AHRQ QI software uses POA data in calculating indicators, the MHS did not begin to collect POA information in MDR until December 2010 (TRICARE Management Activity, 2011-b). Earlier studies showed that incorporating POA data decreased incidences of adverse PSIs (Houchens et al., 2008; Rivard et al., 2010) and IQIs (Pine, 2007). Although POA were not

available for studies during the early part of the wars in Iraq and Afghanistan, they should be incorporated in future uses of quality assessment in military hospitals utilizing AHRQ QIs. There were other data limitations in defining and operationalizing the variables for the study. For example, the variable Clinician Staffing included both inpatient and outpatient clinician FTEs due to limitations in the database for isolating time spent working exclusively in the inpatient areas. A similar issue arose in isolating Deployed FTEs since it was not evident whether the person deploying was from the inpatient or outpatient work centers.

Since AHRQ QIs use administrative data, some have raised concerns whether low performance in quality using AHRQ QIs is attributable to coding practices or due to actual problems with health care quality (Hussey et al., 2006). Formal validation studies have been conducted in the Veterans Health Affairs in an effort to validate that the AHRQ QI software appropriately identifies the adverse events when compared to medical chart reviews (Kaafarani et al., 2011; Cevasco et al., 2011). Among the PSIs validated, three matched the PSIs in this study: Post Operative PE/DVT (PSI 12), Accidental Puncture or Laceration (PSI 15), and Postoperative Wound Dehiscence (PSI 14). Of the adverse events identified by the AHRQ QI software, 43% of PSI 12 and 85% of PSI 15 were validated as true adverse events by chart reviews (Kaafarani et al., 2011). For PSI 14, 87% of identified events were validated by chart reviews (Cevasco, et al. 2011). However, no validation studies have been completed to date in military hospitals. Future studies should validate quality indicators with a sample of medical records to ensure sensitivity and specificity of the AHRQ QI methodology in military hospitals.

In utilizing structural contingency theory, due to the long period of time for each measurement time period (one year), there most likely are incremental increases and decreases that modify fit with the contingencies and the environment which then lead to small structural

modifications that were not captured with the multilevel mixed effects model as applied in this study. Smaller time periods of months or quarters may show fluctuation patterns that annual time periods mask. Due to the small occurrences of some of the adverse events in AHRQ PSIs and IQIs, the researcher opted to keep the annual time period. In future studies, using fewer and more targeted outcomes such as patient falls, medication errors, and pressure ulcer prevalence should be analyzed with smaller time periods to identify these adaptations that structural contingency theory proposes.

In addition, changes in productivity or quality may be due to other variables not captured in this study. There may be differences in skill and training of personnel, equipment and financial resources. The implementation of TeamSTEPPS that occurred at a few military hospitals during the study period was not accounted for in the analysis. These hospitals may have an advantage in communication and coordination, which has been linked to high quality care in AMI mortality (Curry et al., 2011). Future studies could use the ward (medical ward, surgical intensive care unit, etc.) as the unit of analysis to form a three-level analysis in order to incorporate wards that have implemented TeamSTEPPS to account for one more interorganizational variability that may currently be masked at the hospital level. Adding another level to the analysis will enable future researchers to stratify surgical versus medical inpatient quality indicators depending on the type of ward. A smaller organizational unit of analysis may also enable comparison of the AHRQ QIs with data from the Military Nursing Outcomes Database (MilNOD; Patrician, 2010) utilizing nursing sensitive indicators at the unit level such as staff mix and nursing experience as well as unit level outcomes such as falls and pressure ulcer prevalence. In addition, utilizing the survey data collected with implementation of TeamSTEPPS (TeamSTEPPS Teamwork Perception Questionnaire and TeamSTEPPS

Teamwork Attitudes Questionnaire, AHRQ, 2012) will provide another dimension to the research that claims data alone may not be able to capture.

Another possibility may be that adaptation occurs not according to the SARFIT model, but instead in accordance with Child's (1972) Strategic Choice Model where fit with the contingencies may arise from changing the contingencies versus changing structure. Future studies of quality and productivity in military hospitals should incorporate measures of organizational culture and senior management commitment to high quality care following in the footsteps of Curry and colleagues (2011). Information on organizational culture and strategic choice may help to explain more of the variation in quality indicators between military hospitals than what this study, only using secondary data analysis, was able to identify.

The MHS also began to collect electronically all care provided at deployed combat support hospitals as the infrastructure in theater improved during the course of the wars in Iraq and Afghanistan. It would be interesting to compare quality indicators and measures between deployed hospitals and permanent military hospitals. In addition, all patients transferred to and from acute care hospitals were excluded in this study to reduce bias in calculating adverse events. These excluded patients would consist of many of the seriously wounded service members transferred to United States hospitals to recuperate from Germany. With the maturation of the information systems in the theater of operations, another study could be conducted to follow the quality of care provided to these wounded service members from treatment in deployed hospitals in Iraq and Afghanistan all the way through the evacuation system to final discharge at a United States based hospital. Such a study would provide another dimension to the impact of the wars in Iraq and Afghanistan on military hospital performance.

Finally, outpatient care is an important aspect of military hospital performance. This study focused on inpatient services because outpatient quality data were unavailable for the whole time period. The impact of war on outpatient quality and productivity in military facilities would be an important addition to the literature. Since the MHS is an integrated healthcare system with direct control over ambulatory care, it would be the ideal system to test episode-based performance measurement.

Conclusion

In conclusion, this research provides some evidence of differences in productivity and quality based on teaching status of military hospitals in a period of conflict. Military hospitals were able to address the jolt of war with variation in their adaptive capacity. Of the war related predictors, only percentage of wounded patients were associated with one dependent variable, productivity. For military hospitals, teaching status was the variable most associated with hospital quality of care similar to previous studies (Jha et al., 2005; Rivard, et al., 2010; Vartak et al., 2008). Non-teaching hospitals (especially when overseas hospitals are also included as non-teaching hospitals) when compared to major teaching hospitals influenced hospital performance. Although many of the hypothesized relationships were not realized in the multilevel analysis of productivity and quality, the study was a good first step in utilizing national quality measures with MHS data. This study has identified numerous other avenues of research into military hospital performance. As data collection and data warehousing improve, future studies will be able to overcome many of the data limitations identified in this study.

References

ACGME. (2007). Accreditation Council for Graduate Medical Education. Retrieved from http://www.acgme.org/

AHRQ. (2006-a, October 13). *2006 Quality Indicators LISTSERV Broadcast.* Retrieved from Agency for Healthcare Research and Quality: http://www.qualityindicators.ahrq.gov/listserv_archive_2006.htm#Oct13

AHRQ (2006-b). *Quality indicators introduction.* Retrieved from Agency for Healthcare Research and Quality: http://www.qualityindicators.ahrq.gov/introduction.htm

AHRQ. (2007). Key Themes and Highlights From the National Healthcare Quality Report. Retrieved from Agency for Healthcare Research and Quality: http://www.ahrq.gov/qual/nhqr06/nhqr06high.pdf

AHRQ. (2008, April). Health care efficiency measures: Identification, categorization, and evaluation: Final Report. AHRQ Publication No. 08-0030. Retrieved from Agency for Healthcare Research and Quality: http://www.ahrq.gov/qual/efficiency/

AHRQ. (2012). *TeamSTEPPS: National Implementation*. Retrieved from Agency for Healthcare Research and Quality: http://teamstepps.ahrq.gov/

Aiello, K. (2005). Recommendation Analysis for an Ambulatory Surgical Center at Brooke Army Medical Center. ADA443962: Baylor University.

Alexander, J.A., Bloom, J.R., & Nuchols, B.A. (1994). Nursing turnover and hospital efficiency: An organization-level analysis. *Industrial Relations*, 33(4), 505-520. doi:10.1111/j.1468-232X.1994.tb00355.x

Allison, J. J., Kiefe, C. I., Weissman, N. W., Person, S. D., Rousculp, M., Canto, J. G., et al. (2000). Relationship of hospital teaching status with quality of care and mortality for medicare patients with acute MI. *JAMA*, 284(10), 1256-1262. doi:10.1001/jama.284.10.1256

Alonso, A. (2006). Reducing medical error in the military health system: How can team training help? *Human Resource Management Review*, 16(3), 396-415. doi:10.1016/j.hrmr.2006.05.006

American Medical Association. (2007). *FREIDA Online.* Retrieved from http://www.ama-assn.org/vapp/freida/srch/

Army Medicine. (2006). *Levels of Care/Command and Control*. Retrieved from http://www.armymedicine.army.mil/hc/medfacilities/ CommandControl.htm

Association of American Medical Colleges. (2005, November). *Council of Teaching Hospitals and Health Systems (COTH): Membership Listing.* Retrieved from https://www.aamc.org/members/coth/106186/coth_promo.html

Association of American Medical Colleges. (2011). *About COTH.* Retrieved from https://www.aamc.org/members/coth/about/

Atkinson, G. (2011, March). *Current & Future Prospective Payment System*. Presentation during TRICARE Data Quality Course. Retrieved from TRICARE Management Activity: http://www.tricare.mil/ocfo/mcfs/dqmcp/documents.cfm

Beauvais, B., Wells, R., Vasey, J. & Dellifraine, J. L. (2007). Does money really matter? The effects of fiscal margin on quality of care in military treatment facilities. *Hospital Topics,* 85(3), 2-15. doi:10.3200/HTPS.84.2.20-29

Bliese, P. D., & Ployhart, R. E. (2002). Growth modeling using random coefficient models: Model building, testing, and illustrations. *Organizational Research Methods,* 5(4), 362-387. doi:10.1177/109442802237116

Bliese, P D., Wright, K.M., Adler, A.B., Thomas, J.L., & Hoge, C.W. (2007). Timing of postcombat mental health assessments. *Psychological Services*, 4(3), 141-148. doi:10.1037/1541-1559.4.3.141

Bloom, A., & Duren, R. (2003, June 10). *'Wheels Down': FH-3 Arrives Home to Heroes' Welcome.* Retrieved from Navy NewsStand: http://www.navy.mil/search/display.asp?story_id=7900

Borzecki, A. M., Christiansen, C. L., Loveland, S., Chew, P., & Rosen, A. K. (2010). Trends in the inpatient quality indicators: the Veterans Health Administration experience. *Medical care*, *48*(8), 694-702. doi: 10.1097/MLR.0b013e3181e419e3

Bowman, S. (2003, October 2). *Iraq: U.S. Military Operations.* Retrieved from CRS Report for Congress: http://fpc.state.gov/documents/organization/25375.pdf

Cancio, L., Horvath, E., Barillo, D., Kopchinski, B., Charter, K., & Montalvo, A. (2005). Burn support for Operation Iraqi Freedom and related operations, 2003 to 2004. *Journal of Burn Care & Rehabilitation*, 26(2),151-161. doi: 10.1097/01.BCR.0000155540.31879.FB

Castle, N.G., & Engberg, J. (2005). Staff turnover and quality of care in nursing homes. *Medical Care*, 43(6), 616-626.

Centers for Medicare and Medicaid Services. (2010). *Acute Inpatient-Files for Download.* Retrieved from https://www.cms.gov/AcuteInpatientPPS/FFD/list.asp#TopOfPage

Centers for Medicare and Medicaid Services. (2011). *Hospital Compare.* Retrieved from http://www.hospitalcompare.hhs.gov

Cevasco, M., Borzecki, A. M., McClusky III, D. A., Chen, Q., Shin, M. H., Itani, K. M. F., & Rosen, A. K. (2011). Positive predictive value of the AHRQ patient safety indicator "Postoperative wound dehiscence". *Journal of the American College of Surgeons, 212*(6), 962-967. doi: 10.1016/j.jamcollsurg.2011.01.053

Child, J. (1972). Organizational structure, environment and performance: The role of strategic choice. *Sociology*, 6(1), 1-22. doi:10.1177/003803857200600101

Clement, J. P., Valdmanis, V.G., Bazzoli, G.J., Zhao, M., & Chukmaitov, A. (2008). Is more better? An analysis of hospital outcomes and efficiency with a DEA model of output congestion. *Health Care Management Science*, 11(1), 67-77. doi:10.1007/s10729-007-9025-8

CNN. (2003, May 2). *Bush calls end to 'major combat.'.* Retrieved from http://www.cnn.com/2003/WORLD/meast/05/01/sprj.irq.main/

Cobourn, C., Mumford, D., Chapman, M. & Wells, L. (2010). Laparoscopic gastric banding is safe in outpatient surgical centers. *Obesity Surgery*, 20(4), 415-422. doi: 10.1007/s11695-009-0065-7

Cohen, J., Cohen, P., West, S. G., & Akien, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences.* Mahwah, N.J.: Lawrence Erlbaum Associates.

Coffey, R., Barrett, M., Houchens, R., Moy, E., Ho, K., Andrews, R., & Moles, E. (2010). *Methods Applying AHRQ Quality Indicators to Healthcare Cost and Utilization Project (HCUP) Data for the Eighth (2010) National Healthcare Quality Report (NHQR) and National Healthcare Disparities Report (NHDR)*. HCUP Methods Series Report # 2010-06. Retrieved from Agency for Healthcare Research and Quality: http://www.hcup-us.ahrq.gov/reports/methods/methods.jsp

Congressional Budget Office. (2011, June). *Long term implications of the 2012 future years defense program*. Retrieved from Congressional Budget Office: http://www.cbo.gov/publication/41535

Coventry, J., Gromadzki, R., Hutchinson, K., Kiernan, M., Rogers, S., Smith, G., & Spivey, P. (1995) *MHSS Workload Primer*. Retrieved from TRICARE: http://www.tricare.mil/org/pae/primword.html

Curry, L. A., Spatz, E., Cherlin, E., Thompson, J. W., Berg, D., Ting, H. H., ... & Bradley, E. H. (2011). What distinguishes top-performing hospitals in acute myocardial infarction

mortality rates? A qualitative study. *Annals of Internal Medicine, 154*(6), 384-390. doi:10.7326/0003-4819-154-6-201103150-00003

Defense Base Closure and Realignment Commission. (2005). *2005 Defense Base Closure and Realignment Commission Final Report to the President*. Retrieved from http://www.brac.gov/Finalreport.html

Department of the Army. (1995, March 1). *Army Regulation 601-142, Army Medical Department Professional Filler System*. Retrieved from http://www.whs.mil/library/mildoc/AR%20601-142,%201%20March%201995.pdf

Department of Defense. (2003, November 4). *Ground Troop Rotation Plan.* Retrieved from http://www.defenselink.mil/dodcmsshar/briefingslide/ 59/031106-D-6570C-004.jpg

Department of Defense. (2004, December 14). *News release: DoD announces OEF/OIF rotational units.* Retrieved from http://www.defenselink.mil/releases/release.aspx?releaseid=8061

Donaldson, L. (1987). Strategy and structural adjustment to regain fit and performance: In defence of contingency theory. *Journal of Management Studies*, 24(1), 1-24. doi:10.1111/j.1467-6486.1987.tb00444.x

Donaldson, L. (2001). *The contingency theory of organizations.* Thousand Oaks, CA: Sage Publications.

Drösler, S. E., Klazinga, N. S., Romano, P. S., Tancredi, D. J., Aoiz, M. A. G., Hewitt, M. C., ... & Kelley, E. (2009). Application of patient safety indicators internationally: A pilot study among seven countries. *International Journal for Quality in Health Care*, *21*(4), 272-278. doi: 10.1093/intqhc/mzp018

Duffield, C., Diers, D., O'Brien-Pallas, L., Aisbett, C., Roche, M., King, M., & Aisbett, K. (2011). Nursing staffing, nursing workload, the work environment and patient outcomes. *Applied Nursing Research*, *24*(4), 244-255. doi: 10.1016/j.apnr.2009.12.004

Erbes, C., Westermeyer, J., Engdahl, B., & Johnsen, E. (2007). Post-traumatic stress disorder and service utilization in a sample of service members from Iraq and Afghanistan. *Military Medicine, 172*(4), 359-363.

Federal Register. (2010, December 20). Volume 75, No. 243. Retrieved from TRICARE website: http://www.tricare.mil/drgrates/

Felker, B., Hawkins, E., Dobie, D., Gutierrez, J. & McFall, M. (2008). Characteristics of deployed Operation Iraqi Freedom military personnel who seek mental health care. *Military Medicine*, 173(2), 155-158.

Fine, J. M., Fine, M. J., Galusha, D., Petrillo, M., & Meehan, T. P. (2002). Patient and hospital characteristics associated with recommended processes of care for elderly patients hospitalized with pneumonia: Results from the Medicare quality indicator system pneumonia module. *Archives of Internal Medicine*, *162*(7), 827. doi:10.1001/archinte.162.7.827

Farjoodi, P., Skolasky, R. L., & Riley, L. H. (2011). The effects of hospital and surgeon volume on postoperative complications after lumbar spine surgery. *Spine*, *36*(24), 2069-2075.

Fox, C., Gillespie, D., O'Donnell, S., Rasmussen, T., Goff, J., Johnson, C., et al. (2005). Contemporary management of wartime vascular trauma. *Journal of Vascular Surgery*, 41(4), 638-644. doi:10.1016/j.jvs.2005.01.010

Frees, E. W. (2004). *Longitudinal and panel data.* Cambridge: Cambridge University Press.

Fulton, L. V., Lasdon, L.S., McDaniel, R.R., & Coppola, N. (2008). Including quality, access, and efficiency in healthcare cost models. *Hospital Topics, 86*(4), 3-16. doi:10.3200/HTPS.86.4.3-17

Fulton, L., Lasdon, L.S., & McDaniel, R.R. (2007). Cost drivers and resource allocation in military health care systems. *Military Medicine, 172*(3), 244-249.

Gibbons, S. W., Hickling, E. J. and Watts, D. D. (2012). Combat stressors and post-traumatic stress in deployed military healthcare professionals: An integrative review. *Journal of Advanced Nursing*, 68(1), 3-21. doi: 10.1111/j.1365-2648.2011.05708.x

Glisson, C.A. & Martin, P.Y. (1980). Productivity and efficiency in human service organizations as related to structure, size, and age. *Academy of Management Journal*, 23(1), 21-37.

Goldberg, M. S. (2010). Death and injury rates of US military personnel in Iraq. *Military Medicine*, 175(4), 220-226.

Grieger, T. A., Kolkow, T. T., Spira, J. L., & Morse, J. S. (2007). Post-traumatic stress disorder and depression in health care providers returning from deployment to Iraq and Afghanistan. *Military Medicine*, *172*(5), 451-455.

Hagerty, B M., Willams, R.A., Bingham, M. & Richard, M. (2011). Military nurses and combat-wounded patients: A qualitative analysis of psychosocial care. *Perspectives in Psychiatric Care*, 47(2), 84-92. doi: 10.1111/j.1744-6163.2010.00275.x

Halm, E. A., Lee, C., & Chassin, M. R. (2002). Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Annals of Internal Medicine* 137(6), 511–520.

Hannan, M. T., & Freeman, J. (1984). Structural inertia and organizational change. *American Sociological Review*, 49(2), 149-164.

Harrison, J. P., & Coppola, M. N. (2007). Is the quality of hospital care a function of leadership? *The Health Care Manager*, 26(3), 263-272. doi:10.1097/01.HCM.0000285019.56891.df

Hayes, L. J., O'Brien-Pallas, L., Duffield, C., Shamian, J., Buchan, J., Hughes, F, et al. (2006). Nurse turnover: A literature review. *International Journal of Nursing Studies*, 43(2), 237-263. doi:10.1016/j.ijnurstu.2005.02.007

Heltemes, K. J. (2011). Inpatient hospitalizations of US military personnel medically evacuated from Iraq and Afghanistan with combat-related traumatic brain injury. *Military Medicine, 176*(2), 132-135.

Hoge, C., Auchterlonie, J., & Milliken, C. (2006). Mental health problems, use of mental health services, and attrition from military service after returning from deployment to Iraq or Afghanistan. *JAMA*, 295(9), 1023-1032. doi:10.1001/jama.295.9.1023

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *New England Journal of Medicine*, 351(1), 13-22. doi:10.1056/NEJMoa040603

Hollingsworth, B. (2003). Non-parametric and parametric applications measuring efficiency in health care. *Health Care Management Science*, 6(4), 203-218.

Hollingsworth, B. (2008). The measurement of efficiency and productivity of health care delivery. *Health Economics,* 17(10), 1107. doi:10.1002/hec.1391

Hunter, C.S. (2010, January 26). "Sharing Knowledge: Achieving Breakthrough Performance." Presentation given during the 2010 Military Health System Conference Retrieved from http://www.health.mil/Libraries/2010_MHS_Conference_Presentations_-_Jan_26/T32_C_Hunter.pdf

Hussey, P.S., Mattke, S., Morse, L., & Ridgely, M.S. (2006, October). Evaluation of the use of AHRQ and other quality indicators. AHRQ Publication No. 08-M012-EF, December 2007. Retrieved from Agency for Healthcare Research and Quality: http://www.ahrq.gov/about/evaluations/qualityindicators/

Hussey, P. S. De Vries, H., Romley, J., Wang, M.C., Chen, S.S., Shekelle, P.G., & McGlynn, E.A. (2009). A systematic review of health care efficiency measures. *Health Services Research,* 44(3), 784. doi:10.1111/j.1475-6773.2008.00942.x

Institute of Medicine. (1990). *Medicare: A strategy for quality assurance, volume I.* Washington, D.C.: National Academy of Sciences.

Institute of Medicine. (1999). *To err is human: Building a safer health system.* Washington D.C.: National Academy of Sciences.

Jha, A. K., Li, Z., Orav, E. J., & Epstein, A. M. (2005). Care in U.S. Hospitals -- The Hospital Quality Alliance Program. *New England Journal of Medicine*, 353(3), 265-274.

Jha, A. K. Orav, E.J., Dobson, A., Book, R.A. & Epstein, A.M. (2009). Measuring efficiency: The association of hospital costs and quality of care. *Health Affairs*, 28(3), 897-906. doi:10.1377/hlthaff.28.3.897

The Joint Commission. (2013, March 11). "Venous thromboembolism." Retrieved from http:// http://www.jointcommission.org/venous_thromboembolism/

Johnson, K. & Tan, M. (2007, April 11). "Corps: Marine Iraq tours won't change" Marine Corps Times. Retrieved http://www.marinecorpstimes.com/news/2007/04/ marine_iraq_extension_070411/

Johnson,T., Shah, M., Rechner, J. & King, G. (2008). Evaluating the effect of resident involvement on physician productivity in an academic general internal medicine practice. *Academic Medicine*, 83(7), 670-674. doi:10.1097/ACM.0b013e3181782c68

Kaafarani, H. M. A., Borzecki, A. M., Itani, K. M. F., Loveland, S., Mull, H. J., Hickson, K., . . . Rosen, A. K. (2011). Validity of selected patient safety indicators: Opportunities and concerns. *Journal of the American College of Surgeons, 212*(6), 924-934. doi: 10.1016/j.jamcollsurg.2010.07.007

Kauvar, D. S., Wolf, S. E., Wade, C. E., Cancio, L. C., Renz, E. M., & Holcomb, J. B. (2006). Burns sustained in combat explosions in Operations Iraqi and Enduring Freedom (OIF/OEF explosion burns). *Burns*, 32, 853-857.

Kenny, D J. & Hull, M.S. (2008). Critical care nurses' experiences caring for the casualties of war evacuated from the frontline: Lessons learned and needs identified. *Critical Care Nursing Clinics of North America*, 20(1), 41-49.

Kiley, K. C. (2006, November 17). Memorandum: *Fiscal Year (FY) 2008-2010 Business Planning Guidance*.

Kok, B. C., Herrell, R.K., Thomas, J.L., & Hoge, C.W. (2012). Posttraumatic stress disorder associated with combat service in Iraq or Afghanistan: Reconciling prevalence differences between studies. *The Journal of Nervous and Mental Disease, 200*(5), 444-450. doi:10.1097/NMD.0b013e3182532312

Laine, J., Finne-Soveri, U., Björkgren, M., Linna, M., Noro, A., & Häkkinen, U. (2005). The association between quality of care and technical efficiency in long-term care. *International Journal for Quality in Health Care*, 17(3), 259-267.

Landon, B., Normand, S., Lessler, A., O'Malley, A., Schmaltz, S., Loeb, J., et al. (2006). Quality of care for the treatment of acute medical conditions in US hospitals. *Archives of Internal Medicine*, 166(22):2511-2517. doi:10.1097/NMD.0b013e3182532312

Linna, M. (1998). Measuring hospital cost efficiency with panel data models. *Health Economics*, 7(5), 415–427.

Linton, A., & Peterson, M. (2004). Effect of preexisting chronic disease on primary cesarean delivery rates by race. *Birth*, 31(3),165-75. doi:10.1111/j.0730-7659.2004.00301.x

Linton, A., Peterson, M., & Williams, T. (2005). Clinical case mix adjustment of cesarean deliver rates in U.S. military hospitals. *Obstetrics and Gynecology*, 105(3), 598-606. doi:10.1097/01.AOG.0000149158.21586.58

Longest Jr, B B. (1977). Productivity in the provision of hospital services: A challenge to the management community. The *Academy of Management Review*, 2(3), 475-483.

Luft, H. S., Hunt, S. S., & Maerki, S. C. (1987). The volume-outcome relationship: Practice-makes-perfect or selective-referral patterns? *Health Services Research*, *22*(2), 157-182.

Lurie, P. (2008). Analysis and forecasts of TRICARE costs. Retrieved from Institute for Defense Analyses Website: https://www.ida.org/upload/research%20notes/rn_fall2008_tricare.pdf

Mandiakis, N., Hollingsworth, B., & Thanassoulis, E. (1999). The impact of the internal market on hospital efficiency, productivity and service quality. *Health Care Management Science*, 2(2), 75–85.

McLay, R N., Klam , W.P., & Volkert, S.L. (2010). Insomnia is the most commonly reported symptom and predicts other symptoms of post-traumatic stress disorder in us service members returning from military deployments. *Military Medicine*, 175(10), 759-762.

Meyer, A. (1982). Adapting to environmental jolts. *Administrative Science Quarterly*, 27(4), 515-537.

Military Health System. (2006). *MHS Strategic Plan: Roadmap to Medical Transformation*. Retrieved from Military Health System Website: http://fhp.osd.mil/pdfs/MHS%20QDR%20Medical%20Transformation%20Roadmap.pdf

Military Health System. (2008). *MHS Strategic Plan: Roadmap to Medical Transformation*. Retrieved from Military Health System Website: http://www.health.mil/Libraries/Documents_Word_PDF_PPT_etc/2008_Strat_Plan_Final_-lowres.pdf

Military Health System. (2012). MHS Stakeholders' report. Retrieved from Military Health System: http://www.health.mil/About_MHS/StakeholdersReport.aspx

Monson, C. M., Taft, C. T., & Fredman, S. J. (2009). Military-related PTSD and intimate relationships: From description to theory-driven research and intervention development. *Clinical Psychology Review*, *29*(8), 707-714. doi: 10.1016/j.cpr.2009.09.002v

Montgomery, S. P., Swiecki, C. W., & Shriver, C. D. (2005). The evaluation of casualties from Operation Iraqi Freedom on return to the continental United States from March to June 2003. *Journal of the American College of Surgeons*, 201(1), 7-12. doi:10.1016/j.jamcollsurg.2005.03.038

Morey, J. C., Simon, R., Jay, G.D., Wears, R.L., Salisbury, M., Dukes, K.A., & Berns, S.D. (2002). Error reduction and performance improvement in the emergency department through formal teamwork training: Evaluation results of the medteams project. *Health Services Research*, 37(6), 1553-1581. doi:10.1111/1475-6773.01104

Murray, C., Reynolds, J., Schroeder, J., Harrison, M., Evans, O., & Hospenthal, D. (2005). Spectrum of care provided at an echelon II Medical Unit during Operation Iraqi Freedom. *Military Medicine*, 170(6), 516-520.

O'Brien-Pallas, L., Griffin, P., Shamian, J., Buchan, J., Duffield, C., Hughes, F., Laschinger, H., North, N., Stone, P. (2006). The impact of nurse turnover on patient, nurse, and system outcomes: A pilot study and focus for a multicenter international study. *Policy, Politics & Nursing Practice*, 7(3), 169-179.

Office of the Assistant Secretary of Defense Health Affairs. (2008, April 7). *DoD 6010.13-M: Medical Expense And Performance Reporting System For Fixed Military Medical And Dental Treatment Facilities.* Retrieved from MEPRS: https://www.meprs.info/files/meprs6010.pdf?CFID=291012&CFTOKEN=35744689

Office of the Surgeon General. (2008). ALARACT 005/2008. SUBJECT: 180-day professional filler system (PROFIS) deployment policy ISO OIF/OEF. Retrieved from Army G1 Website: http://www.armyg1.army.mil/MilitaryPersonnel/PPG/Hyperlinks/ Adobe%20Files/ALARACT%20005%202008.pdf

Oliver, D. K., Swanson, S. J., Yuan, C. L., & Welch, P. G. (1999). The Walter Reed Army Medical Center outpatient infusion service: Lessons for managing health care change at the local level. *Military Medicine*, 164(10), 688-692.

Olsen, J., & Coleman, J. R. (2001). Using Continuous quality improvement techniques to determine the causes of hospital readmission. *Critical Care Nurse*, 21 (2), 52-59.

Ozcan, Y. (2009). *Quantitative methods in health care management (2nd ed).* San Francisco, CA: Jossey-Bass.

Ozcan, Y.A. (2008). *Health care benchmarking and performance evaluation.* New York: Springer.

Park, S. H. (2012). Patient turnover and the relationship between nurse staffing and patient outcomes. *Research in Nursing Health, 35*(3), 277. doi:10.1002/nur.21474

Patrician, P. A. (2010). Organizational determinants of work outcomes and quality care ratings among army medical department registered nurses. *Research in Nursing Health, 33*(2), 99. doi:10.1002/nur.20370

Pine, M., Jordan, H.S., Elixhauser, A., Fry, D.E., Hoaglin, D.C., Jones, B., Meimban, R., Warner, D., & Gonzales, J. (2007). Enhancement of claims data to improve risk adjustment of hospital mortality. *JAMA, 297*(1), 71-76. doi:10.1001/jama.297.1.71

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods.* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Rivard, P. E., Rosen, A. K., & Carroll, J. S. (2006). Enhancing patient safety through organizational learning: Are patient safety indicators a step in the right direction? *Health Services Research,* 41 (4), 1633–1653. doi:10.1111/j.1475-6773.2006.00569.x

Rivard, P.E., Elixhouser,A., Christiansen, C.L., Zhao, S. & Rosen, A.K. (2010). Testing the association between patient safety indicators and hospital structural characteristics in VA and nonfederal hospitals. *Medical Care Research and Review,* 67(3), 321. doi:10.1177/1077558709347378

Rogers, M. (1998, May). *The definition and measurement of productivity.* Retrieved from Melbourne Institute of Applied Economic and Social Research: http://www.melbourneinstitute.com/wp/wp98n9.pdf

Romano, P. S., Geppert, J. J., Davies, S., Miller, M. R., Elixhauser, A., & McDonald, K. M. (2003). A national profile of patient safety in U.S. hospitals. *Health Affairs*, 22(2), 154-166. doi:10.1377/hlthaff.22.2.154

Romano, P. S., Mull, H. J., Rivard, P. E., Zhao, S., Henderson, W. G., Loveland, S., . . . Rosen, A. K. (2009). Validity of selected AHRQ patient safety indicators based on VA national surgical quality improvement program data. *Health Services Research, 44*(1), 182-204. doi: 10.1111/j.1475-6773.2008.00905.x

Scheirman, K. (2001). An analysis of medication errors at the military medical center: Implications for a systems approach for error reduction. ADA420601: Baylor University.

Schnurr, P.P., Lunney, C.A., Bovin, M.J., & Marx, B.P. (2009). Posttraumatic stress disorder and quality of life: Extension of findings to veterans of the wars in Iraq and Afghanistan. *Clinical Psychology Review*, 29(8), 727-735.

Scott, W. R. (2003). *Organizations: Rational, natural, and open systems. (5th ed.).* Upper Saddle River, NJ: Prentice Hall.

Seal, K H., Metzler,T.J., Kristian, S.G., Bertenthal, D., Maguen, S., & Marmar,C.R. (2009). Trends and risk factors for mental health diagnoses among Iraq and Afghanistan veterans using Department of Veterans Affairs health care, 2002-2008. *American Journal of Public Health*, 99(9), 1651-1658.

Singer, J.D., & Willett, J.B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence.* New York: Oxford University Press.

Stewart, D. (2009). Casualties of war: Compassion fatigue and health care providers. *Medsurg Nursing, 18*(2), 91-4.

Svan, J.H. (2010, September 16). “Air Force changes deployment lengths for some 42,000 airmen.” *Stars and Stripes.* Retrieved from http://www.stripes.com/news/air-force-changes-deployment-lengths-for-some-42-000-airmen-1.118444

Tanielian, T L. & Jaycox, L.H. (2008). Invisible wounds of war. RAND: Santa Monica, CA: RAND Corporation.

Tangka, F K., Trogdon, J.G., Richarson, L.C., Howard, D., Sabatino, S.A. & Findelstein, E.A. (2010). Cancer treatment cost in the United States. *Cancer*, 116(14), 3477-3484. doi:10.1002/cncr.25150

Tenuta, J. J. (2006). From the battlefields to the states: the road to recovery. The role of Landstuhl regional medical center in US military casualty care. *Journal of the American Academy of Orthopaedic Surgeons*, *14*(10), S45-S47.

Thomas, J. L., Wilk, J.E., Riviere, L.A., McGurk, D., Castro, C. A., Hoge, C.W. (2010). Prevalence of mental health problems and functional impairment among Active Component and National Guard soldiers 3 and 12 months following combat in Iraq. *Archives of General Psychiatry*, 67(6), 614. doi:10.1001/archgenpsychiatry.2010.54

Tosi, H. L., & Slocum, J. W. (1984). Contingency theory: Some suggested directions. *Journal of Management*, 10(1), 9-26.

TRICARE. (2006, April 4). *2006 TRICARE Stakeholders' Report.* Retrieved from http://www.tricare.mil/stakeholders/statistics.cfm

TRICARE. (2008-a, March 3). *Eligibility*. Retrieved from http://www.tricare.mil/mybenefit/home/overview/Eligibility?

TRICARE. (2008-b). *TRICARE/CHAMPUS DRG-Based Payment System*. Retrieved from http://www.tricare.mil/DRGRates/index.cfm

TRICARE. (2010). *DRG weights and rates*. Retrieved from http://www.tricare.mil/drgrates/

TRICARE Management Activity. (2010, April 30). *MDR Functional User’s Handbook.* Retrieved from TRICARE: http://www.tricare.mil/ocfo/_docs/MDR%20Functional%20User%20Guide%20V2.4%20(04-30-10).pdf

TRICARE Management Activity. (2011-a, October 1). *TRICARE Costs*. Retrieved from http://www.tricare.mil/tma/tricarecost.aspx

TRICARE Management Activity. (2011-b, February). *M2 Data Dictionary*. Retrieved from TRICARE: http://www.tricare.mil/ocfo/BEA/functional_specs.cfm

TRICARE Management Activity. (2011-c, December). MHS Management Analysis and Reporting Tool [online database]. Retrieved from https://tma-bi.csd.disa.mil

TRICARE Management Activity. (2012, May). *TRICARE choices at a glance*. Retrieved from http://www.tricare.mil/tricaresmart/product.aspx?id=856&CID=0&RID=1

Tu JV, Austin PC,Chan BB. (2001). Relationship between annual volume of patients treated by admitting physician and mortality after acute myocardial infarction. *JAMA*, *285*(24), 3116-3122. doi: 10.1001/jama.285.24.3116

Valdmanis, V.G., Rosko, M.D. & Mutter, R.L. (2008). Hospital quality, efficiency, and input slack differentials. *Health Services Research*, *43*(5), 1830-1848. doi:10.1111/j.1475-6773.2008.00893.x

Vartak, S., Ward, M.M., Vaughn, T.E. (2008). Do postoperative complications vary by hospital teaching status? *Medical Care*, *46*(1), 25-32. doi:10.1097/MLR.0b013e3181484927

Warner, C.H., Appenzeller, G.N., Grieger, T., Belenkiy, S., Breitbach, J., Parker, J. et al. (2011). Importance of anonymity to encourage honest reporting in mental health screening after combat deployment. *Archives of General Psychiatry*, *68*(10), 1065-1071. doi:10.1001/archgenpsychiatry.2011.112

Werner, R.M., Bradlow, E.T., & Asch, D.A. (2008). Does hospital performance on process measures directly measure high quality care or is it a marker of unmeasured care? *Health Services Research*, *43*(5), 1464-1484. doi:10.1111/j.1475-6773.2007.00817.x

White, J. M., Stannard A., Burkhardt, G.E., Eastridge, B.J., Blackbourne, L.H., Rasmussen, T.E. (2011). The epidemiology of vascular injury in the wars in Iraq and Afghanistan. *Annals of Surgery*, *253*(6), 1184-1189. doi:10.1097/SLA.0b013e31820752e3

White House. (2003, March 19). *News Release: President Bush Addresses the Nation.* Retrieved from http://www.whitehouse.gov/news/releases/2003/03/20030319-17.html

Wojcik, B. E., Humphrey, R. J., Czejdo, B., & Hassell, L. H. (2008). US Army disease and nonbattle injury model, refined in Afghanistan and Iraq. *Military medicine*, *173*(9), 825-835.

Worthington, A. (2004). Frontier efficiency measurement in health care: a review of empirical techniques and selected applications. *Medical Care Research and Review*, 61(2), 135-170. doi:10.1177/1077558704263796

Wright K.M., Cabrera O.A., Bliese P.D., Adler A.B., Hoge C.W. *&* Castro C.A. *(*2009*)* Stigma and barriers to care in soldiers postcombat. *Psychological Services*, 6*(*2*)*, 108–116. doi:10.1037/a0012620

Zouris, J., Walker, J., Dye, J., & Galarneau, M. (2006). Wounding patterns for U.S. marines and sailors during Operation Iraqi Freedom, major combat phase. *Military Medicine*, 171(3), 246-252.

Vita

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